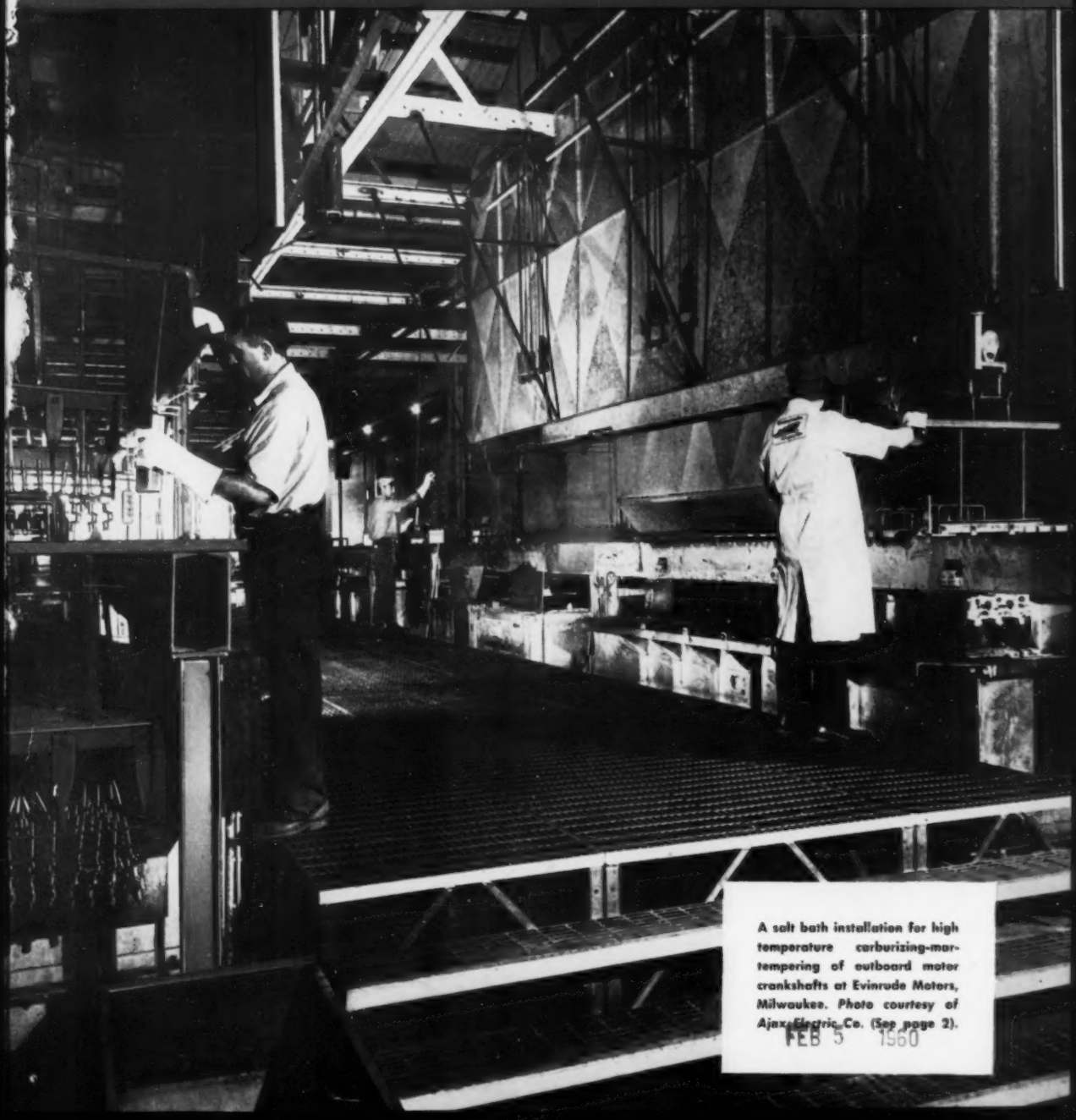
MARCH
APRIL 1959

Metal Treating

THE *ONLY* MAGAZINE DEVOTED EXCLUSIVELY TO THE HEAT TREATING INDUSTRY



A salt bath installation for high temperature carburizing-martempering of outboard motor crankshafts at Evinrude Motors, Milwaukee. Photo courtesy of Ajax Electric Co. (See page 2).

FEB 5 1960

HOLDEN 701
ELECTRODE FURNACE
for fast, economical
salt bath brazing
COPPER • BRASS • SILVER
ALUMINUM • MAGNESIUM

1. CONSISTENT RESULTS

Holden Type 701 furnace provides temperature uniformity regardless of depth. Plus or minus 2½ degrees easily obtained.

2. ECONOMY OF OPERATION

Power consumption reduced 25% because of unique pier design — a feature found only in the Holden 701 furnace.

3. INCREASED PRODUCTION

No interference between work load and electrodes. Unhampered working area allows more production.

4. LONGER ELECTRODE LIFE

Patented Holden split electrode assembly of special alloy gives increased life.

5. LOWER MAINTENANCE

Single bolt connection allows electrodes to be removed and replaced within 20 minutes. Self-contained ceramic pot of high grade refractory lasts longer — can be changed easily.

WRITE FOR BULLETIN No. 201-MT

THE A. F. HOLDEN COMPANY

New Haven, Conn.	Detroit, Mich.	Los Angeles, Calif.
State 7-5885	Broadway 3-5405	Ludlow 1-9153

INDUSTRIAL FURNACES — ELECTRODE FURNACES — POT FURNACES — TRANSFORMERS — SALT BATHS

METAL TREATING

Vol. X No. 2

March-April

☆ ☆ ☆

Editor, C. E. HERINGTON
Asst. Editor, Bus. Mgr.
H. R. HERINGTON

Prod. Mgr., ALYCE J. COLLIER

Publication Committee
Chairman, HORACE C. KNERR
Metlab Company, Philadelphia, Penna.

Members: LLOYD G. FIELD
Greenman Steel Treating Company,
Worcester, Massachusetts

FRED HEINZELMAN, JR.
Fred Heinzelman & Sons, N. Y., N. Y.

NORMAN HODGSON
Alfred Heller Heat Treating Co., Inc.
New York, N. Y.

K. U. JENKS
Lindberg Steel Treating Co.
Melrose Park, Illinois

MICHAEL KOBER
Commercial Metal Treating, Inc.
Bridgeport, Connecticut

CHARLES R. WEIR
Commonwealth Industries, Inc.
Detroit, Michigan

SALES REPRESENTATIVES

CALIFORNIA:
KEITH H. EVANS AND ASSOCIATES
3723 Wilshire Boulevard
Los Angeles 5, California
DUnkirk 8-2981

MID-WEST:
ALFRED W. COLLIER
116 S. Michigan Ave., Chicago 3, Ill.
FInancial 6-1558

NEW ENGLAND:
FREDERIC W. PECK
97 Thornton Street
Hamden 14, Connecticut
CHestnut 8-2233

★ ★ ★

The Metal Treating Institute
Officers — 1959

President, K. U. Jenks
Lindberg Steel Treating Company
Melrose Park, Illinois

Vice-President, Charles R. Weir
Commonwealth Industries, Inc.
Detroit, Michigan

Treasurer, Lloyd G. Field
Greenman Steel Treating Co.
Worcester, Massachusetts

Executive Secretary, C. E. Herington
271 North Avenue
New Rochelle, New York

TABLE OF CONTENTS

ARTICLES

The Prediction of Carburizing Cycles
by E. N. Case 2

Metallurgical Research Develops Improved Products Through Heat Treating
by Helen Hoover 8

FEATURES

News to Heat Treaters ... 16
The Apprentice Corner ... 18
Abstracts 22
M.T.I. Activities 26
What Would *You* Do? ... 32
Manufacturers' Literature . 50
Equipment and Materials Directory 54
Index to Advertisers 56

• • •

Published bimonthly by the Metal Treating Institute, 271 North Avenue, New Rochelle, N. Y. Phone: NE 6-4658.

© 1959 by the Metal Treating Institute. All rights reserved.

Accepted as Controlled Circulation publication at New York, N. Y.

The presentation of editorial material in "Metal Treating" should not be interpreted as either an endorsement or recommendation by the Metal Treating Institute of the statements set forth.

Indexed in Engineering Index

Member of Business Publications Audit of Circulation, Inc.

THE PREDICTION OF CARBURIZING CYCLES

By **E. N. CASE,** Sales Manager
Ajax Electric Company
Philadelphia, Pa.

FOR MOST practical heat treating procedures, there will be more than one way of arriving at the specified results. Carburizing, for example, can be carried out in a solid (pack), liquid (salt), or gas medium, yet the results are much the same irrespective of the medium being used. The basic controls and problems are likewise very similar. This makes it possible to derive principles from one set of conditions and to use them under very different circumstances, provided only that proper adjustments are made for any change in variables. The work to be described here has been based on the use of molten salt baths, since this is the medium with which the writer is most familiar, but, nevertheless, the principles are applicable to any method of carburizing or for consideration of decarburizing conditions which are merely the reverse of carburizing reactions. It will also be shown that data originally developed on a theoretical basis can be used in practical operations, and in addition, can be used to predict results within a reasonable degree of accuracy. The theoretical results can also be used as a check against experimental work and as a means of reducing the number of test specimens required to assure reliable results.

Carburizing Cycles

Let us first review briefly some of the concepts involved in carburizing. One of the basic tools with which the practical heat treater works is a set of curves which relate case depth to time at various temperatures. The temperatures may be limited by the particular furnace equipment which is available, and the curves themselves are obtained by a series of tests on steel samples. The samples are heated for various times and temperatures, the resulting case depths are measured by some suitable method, and the results are plotted on graph paper to give the working curves (see Fig. 1). Such a series of curves is frequently made in the shop based on a particular piece of equipment, since such a method eliminates the possible variables of furnace construction.

In many types of carburizing operations, particularly in batch work, the size of the charge will also affect the results which are obtained, since the work will be carburizing during a portion of the time required to bring the load to heat. If this is a factor, the shop curves should also take load size into consideration. The manufacturers of furnace equipment also publish curves of the same type, but of necessity they must be more general, and the user will modify them based upon experiment and knowledge of his own conditions. Where the furnace equipment is capable of bringing the load to heat rapidly, published curves will frequently suffice since this minimizes the time required for the charge to come to carburizing temperature. If the furnace, on the other hand, is slow to recover, the work may be in a range where it can absorb carbon long before it reaches the set temperature; while the true start of the carburizing cycle cannot be made equal to the time of loading the furnace, neither can it be taken from the time that the load reaches temperature. In processing small charges, this factor may be neglected since the work load is small in proportion to the size of the furnace.

We might mention here that the use of salt bath equipment frequently enables us to neglect this variable since it is practical to stagger loads in such a manner that they will be small compared to the total weight of salt and work in the furnace and so that there will be little drop in furnace temperature. This combines with the rapid heating characteristic of salt to make the heat-up time an almost negligible portion of the total cycle.

Interpretations of "Case Depth"

The term "case depth" has been used above as though it could be determined easily. No one knows better than the commercial heat treater that the term is subject to many interpretations in practice. Some users talk about "total" case, and this value will depend upon the method by which the measurement is made. Others may prefer to use "effective" case, which in turn is measured by a number of different methods; and still others will use a quenched and fractured specimen. The quenched and fractured specimen, particularly for light or moderate case depths, is fairly straightforward to read and little subject to individual errors in interpretation. The fracture specimen has a practical advantage since it shows the portion of the case which will be hardened when quenched in whatever medium is used. It is obvious that the portion of the case which will not harden out on quenching is of little value in most applications. The most precise method is, of course, actually to determine

the carbon gradient in a test bar by turning off samples and analyzing them, plotting the results and determining case depth to some specific carbon level. This, however, is a costly procedure and is primarily relied on for developmental work.

Measuring Carbon Potential

Another useful tool in the study of the carburizing cycle is the use of carbon shim stock or foil. Such a thin specimen comes very rapidly to equilibrium with the surrounding atmosphere and therefore gives a practical and effective means of measuring the carbon potential of the medium which may be defined as the level to which the carburizing medium can raise carbon in steel. Chemical analysis of such foils shows a good correlation with the first cut of a carbon determination bar, and thus has practical uses in carburizing procedures. In some cases, it is possible to weigh the steel foil or fine steel wire on an analytical balance before and after a carburizing procedure and determine the carbon potential by the gain in weight. Other means are also used and may even be employed to control the carburizing potential; such as, the determination of resistance of a carburized steel wire, or the measurement of dew point which in turn can be correlated with the carburizing potential under standardized conditions.

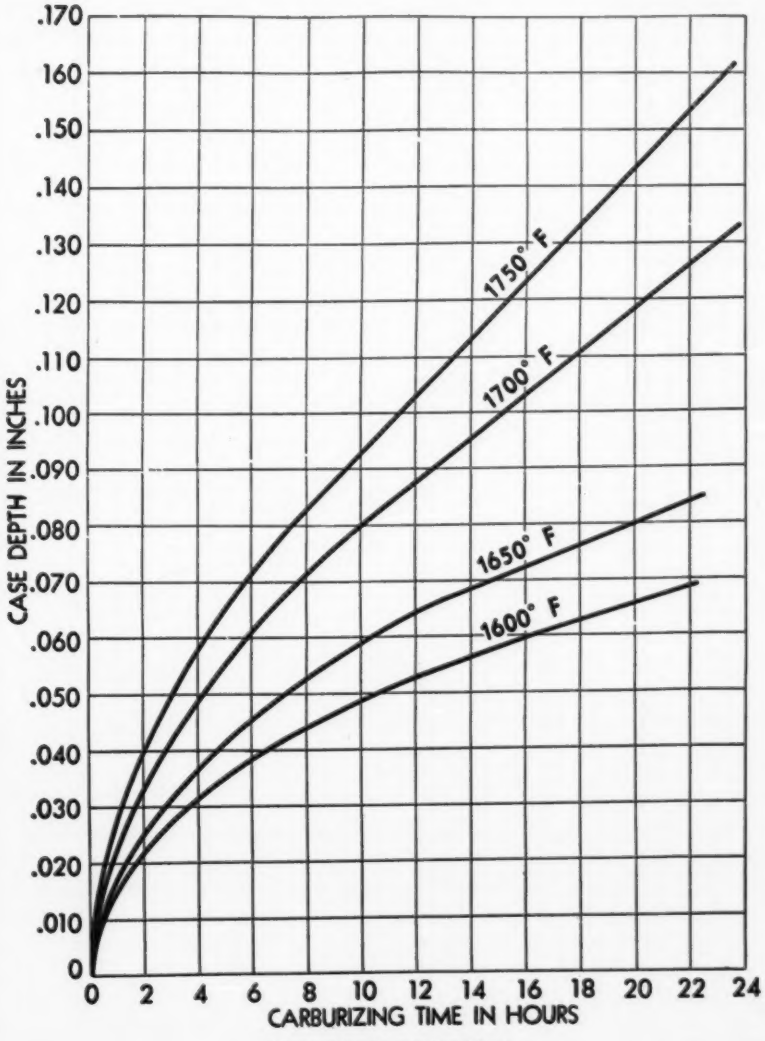


Fig. 1—Time-Penetration Chart

Carbon Solubility

When an attempt is made to study the carburizing reaction, an additional chemical or metallurgical complication is added to those already mentioned. This is the fact that the solubility of carbon in iron depends not only on the alloying elements in the steel being treated, but also on the temperature. Harris has indicated [1] that the maximum carbon at the surface of the part is essentially that of the corresponding austenite solubility curve as shown on the iron-carbon diagram. Excessive carbon potentials will cause sooting in gas atmospheres; this simply implies that more carbon is being produced than the steel is capable of absorbing. The surface carbon has been neglected in the calculations which are to be presented here, but the experimental results show that it does not have a major effect. If it were to be considered, it would have the effect of increasing the calculated penetration rate at higher temperatures and decreasing it slightly at lower ones. It may also be mentioned that the surface carbon mentioned above as maximum may not be produced by any specific carburizing condition, and, therefore, that the results to be discussed are the maximum which can be expected. Lower penetrations may frequently be obtained, but higher ones are unlikely.

Equations of Carburizing

A mathematical interpretation of the carburizing mechanism can be developed from the diffusion laws that put into equation form the idea that the amount of carbon diffusing in a given period of time is proportional to a function of the carbon gradient. However, this equation is of little use directly, and the writer some years ago presented in *Metal Treating* [2] an equation based on

[1] Harris, F. E., *Metals Handbook*, (1948 ed.), pp. 678 ff. and *Metal Progress*, May 1944, pp. 488 ff.

[2] See "A Review of Salt Bath Carburizing" by E. N. Case, *Metal Treating*, vol. VI, no. 3, May-June 1955, pp. 18 ff.

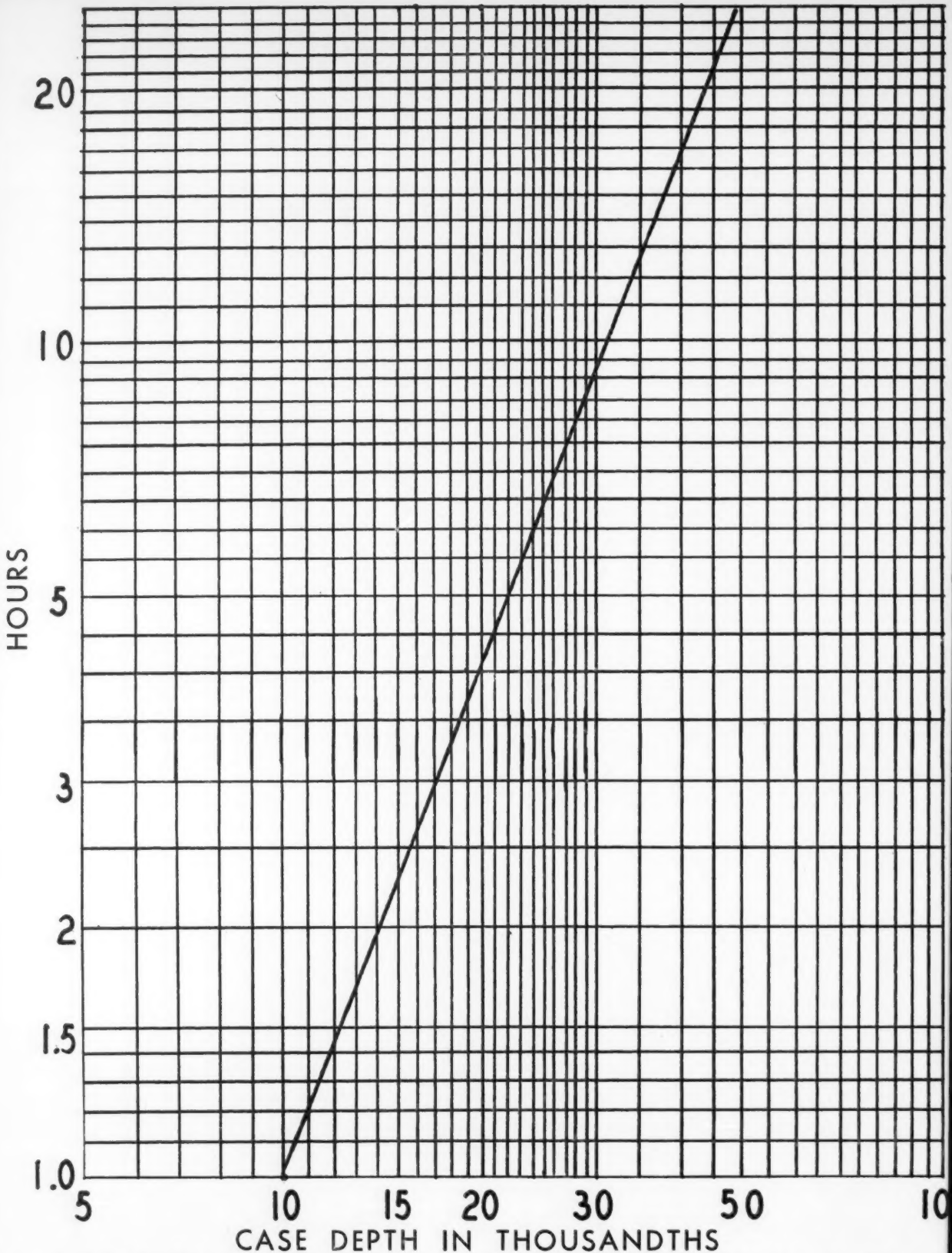


Fig. 2—A log-log plot for case depth against time. A sample of any steel at any time and temperature will determine a point which can be plotted on this chart. A line parallel to that shown, through the point, will predict case depths at other times.

the work of Harris as follows:

$$D = K\sqrt{t}$$

where D is the case depth in thousandths of an inch, t is the time in hours and K has the following maximum values for various temperatures:

1400°F	8
1450°F	10
1500°F	12
1550°F	15
1600°F	18
1650°F	21
1700°F	25
1750°F	29

These values were based on the calculations which Harris reported and may be considered as approximating the maximum total case. This equation has more value in practical carburizing. For example, it shows that the square root of time is involved, and, therefore we must not double the time when we wish to double case depth, but multiply it by two squared or four; to get three times the case requires nine times the carburizing time, and so on. A little further study leads us to a way of obtaining the value of K. The square root of one is one, and thus at one hour the time factor drops out. Therefore, the case depth at one hour gives us a value for K, which takes into account whatever method of measurement of case depth we intend to use. We have, therefore, determined K for the particular steel and conditions involved and can draw up a curve of case depth against time by simply multiplying, using a table of square roots.

Use of the Equation

Let us see what else can be done with this relationship. If the preceding equation is used but we take the logarithm of each side, we have this result—

$$\text{Log } D = \text{Log } K + \tfrac{1}{2} \text{ Log } t$$

This may look complicated, but it is really simple to use since it says that if we plot the logarithm of the case depth against the logarithm of the time, we will get a straight line (See Fig. 2). Moreover, since Log K is also a constant, a straight line at one temperature will be parallel to that at another, and it is also true that steel of varying analyses will produce parallel straight lines when so plotted. We can make use of charts where logarithmic coordinates are available to avoid determining the logarithm of the individual values. With this kind of a relationship, we can draw conclusions with a degree of confidence in the results.

There has been sufficient work done by various individuals to show that these equations, and the results derived from them, are valid and practical. Some years ago, in a book on salt baths, Dupont published data on the case depth at various times with deep case carburizing salts and it was illustrated by just such a plot of logarithmic relationships. Further, the lines were parallel for various steels and for various temperatures as the equation predicted. Similar data have been made available by other suppliers as well. It is apparent that if we can determine the values of K in this equation, and particularly, if we can find some way of determining these values for various temperatures, we can use this relationship to predict, in turn, the case depth for temperatures where experimental information is slight or lacking. This would be a useful and practical type of crystal gazing.

Prediction of Carburizing Rate

The value K in the equation is very similar in nature to that which chemists call the reaction rate constant, and a number of years ago the Dutch chemist, Arrhenius[3], showed that for many reactions and within limited temperature ranges the logarithm of the constant K was proportional to the reciprocal of the absolute temperature. As a means of determining K, this seemed a good place to start. The resultant curve is shown in Fig. 3, and the actual nature of the curve is seen to be essentially a straight line. The dotted portion of the curve is an extension from the previous values into a range where there is presently relatively little experimental data. This lets us further estimate what the maximum carburizing rate would be if conditions were ideal. The following table, Table I, shows in tabular form the results obtained for various temperatures and the times when the formula is applied, using the corresponding values for K as shown for the various temperatures. When these results are plotted, a series of curves is obtained which permits us to predict case depths at higher carburizing temperatures (See Fig. 4).

The bulk of the preceding material has been based on calculation. It is of little use to the practical heat treater if he cannot apply it to his own work and the validity of the reasoning involved should then be proved by experiment. Fortunately, it is possible to do so.

[3]Glasstone, *Textbook of Physical Chemistry*, (1943 ed.), pp. 1067 ff.

TABLE I

		K=12 1500°F	K=18 1600°F	K=26 1700°F	K=35 1800°F	K=47 1900°F	K=62 2000°F
Time	$\sqrt{t}$	D	D	D	D	D	D
½	0.7071	8.5	13	18	25	33	44
1	1.000	12	18	26	35	47	62
2	1.414	17	25	37	49	66	88
3	1.732	21	31	45	61	81	107
4	2.000	24	36	52	70	94	124
5	2.236	27	40	58	78	105	139
6	2.449	29	44	64	86	115	152
7	2.645	32	48	69	93	124	164
8	2.828	34	51	74	99	133	175
9	3.000	36	54	78	105	141	186

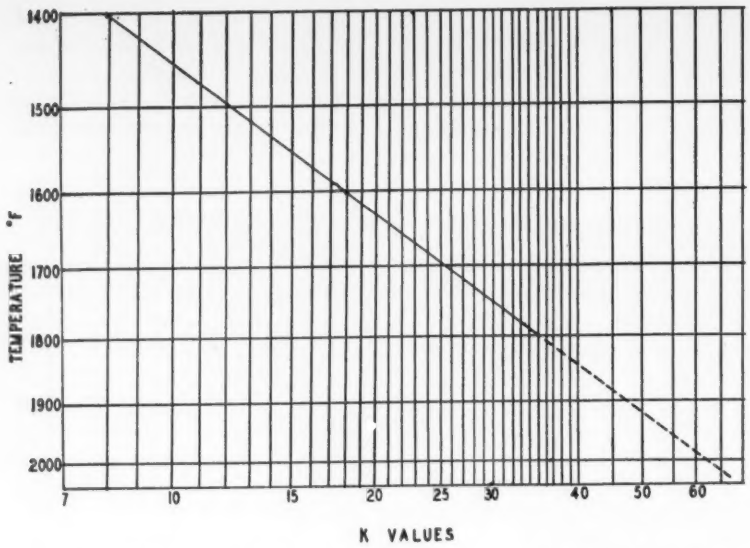


Fig. 3—A straight line results when the logarithm of the K value is plotted against the reciprocal of the absolute temperature.

Validity of the Method

It was mentioned earlier that the use of salt baths as a carburizing medium has the advantage of providing such rapid heat-up time that this otherwise troublesome factor can frequently be neglected. Heat is by conduction so that the reflectivity of a sample is not a matter of any consequence. We have therefore, considered the use of salt baths for the experimental work. Some ten years ago, commercial carburizing was carried out at a temperature in excess of 1700°F which was considered "high" at that time. Two shops, to the knowledge of the writer, operated as high as 1800°F, and their results are available.

In addition, in cooperation with American Cyanamid Company, Park Chemical Company and Carpenter Steel Company, Ajax Electric Company has been carrying out carburizing studies at even higher temperatures. This study is still underway, and the results are not yet available for publication; but data on case depth at a temperature of 1900°F have been obtained. These are based on carbon gradient curves, and the figures shown are obtained by extrapolating the type of plot used by Harris in order to make the results determinable on the same basis as his data. The results obtained are shown in Table II.

TABLE II
(Comparison of calculated and measured case depths)

Time	Calculated	Measured
1800°F		
2 hrs.	49	52
4	70	73
6	86	87
8	99	100
1900°F		
1 hr.	47	48
3	81	83
5	105	107

The results, whether listed in the table or plotted, are seen to be in very close agreement. The same result, of course, would show if the log plot is used, and we therefore have a proved means of predicting carburizing rates under optimum

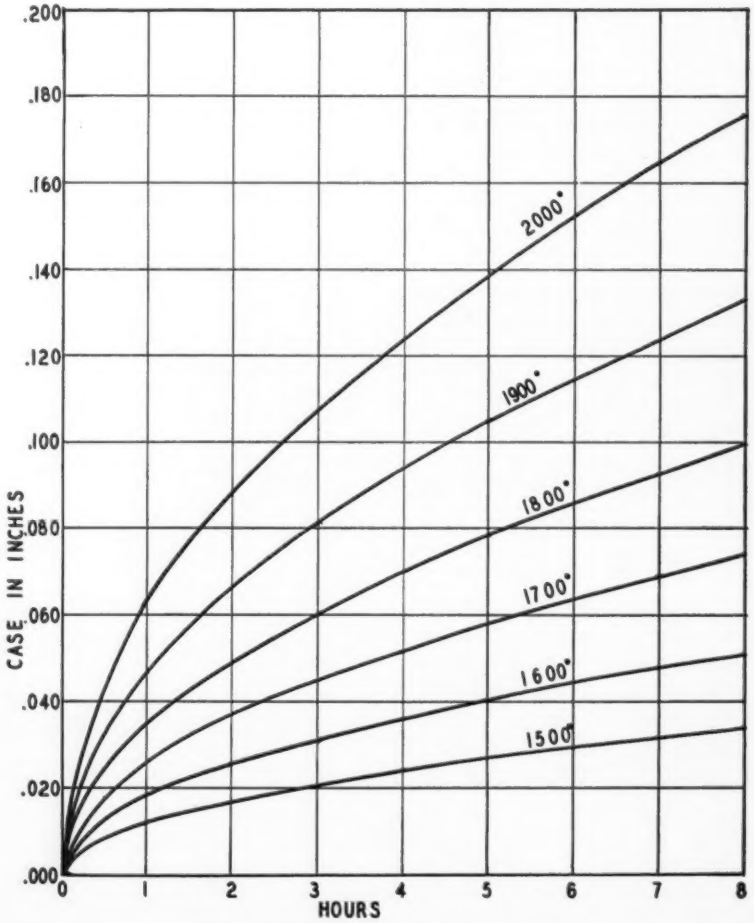


Fig. 4—Plot of the calculated data in Table I.

conditions. Let us reiterate, however, that a longer heat-up time will change the shape of these curves. If total time is measured, they are displaced downward; and if the overall heating time is changed due to a particularly slow cooling rate, they may again be changed. The displacement due to heat-up time is not uniform but is greater at the short-time end of the curve. Thus it is apparent that there would be little difference from this source for charges heated for six or eight hours but it would be substantial for one, two or three hours. Reduced carburizing potential would also have the effect of reducing the penetration rate as well as changing the surface carbon and the carbon gradient of the work.

A plot has been prepared on the log-log scale of reported data from various sources (See Fig. 5). Curve A is material published on SAE-4620 in the *Iron Age*, at 1800°F.[4] Curve B is for 8620 at 1700°F and Curve E for 8620 at 1900°F, both of them reported by Ipsen in *Metal Treating* magazine.[5] The Line C is for SAE-1020 at 1700°F based on data from American Cyanamid Company, and Curve D is from a summary report published in *Metal Progress* for SAE-1018 and 1017 at 1900°F.[6] B and C are for equivalent temperatures as are D and E, and their relative proximity is quite apparent. The reason for the substantial deviation of Curve A has been attributed to the somewhat unusual experimental conditions which were involved in this particular study.

High Temperature Carburizing

The data presented, and in particular the calculated curves, also show the advantages of high temperature carburizing. Since the evidence is rather conclusive that these predictions are valid, we can say with some assurance that results similar to those given in the curves will be experienced in actual tests. Note, for example, that at 1900°F we can obtain a case depth in 1½ hours which would take six hours even at 1700°F. Reduction in time is even greater at higher temperatures. The result, from the users' standpoint, will not only be shorter carburizing cycles but also smaller equipment to handle the same amount of work. Rapid heating to temperature will be a decided advantage when the cycle becomes so short if close control of the case depth is to be obtained. For this reason, we expect that molten salt baths will frequently be seriously considered.

Disadvantages are also foreseen for high temperature carburizing. One of these is the possibility of grain growth, and this is being studied by a number of workers at the present time, although any comments would be preliminary. The shorter time would be expected to compensate at least partially for the higher temperature, and there is some evidence that it will indeed do so although it is expected that there will be a variation from steel to steel.

(Continued on page 39)

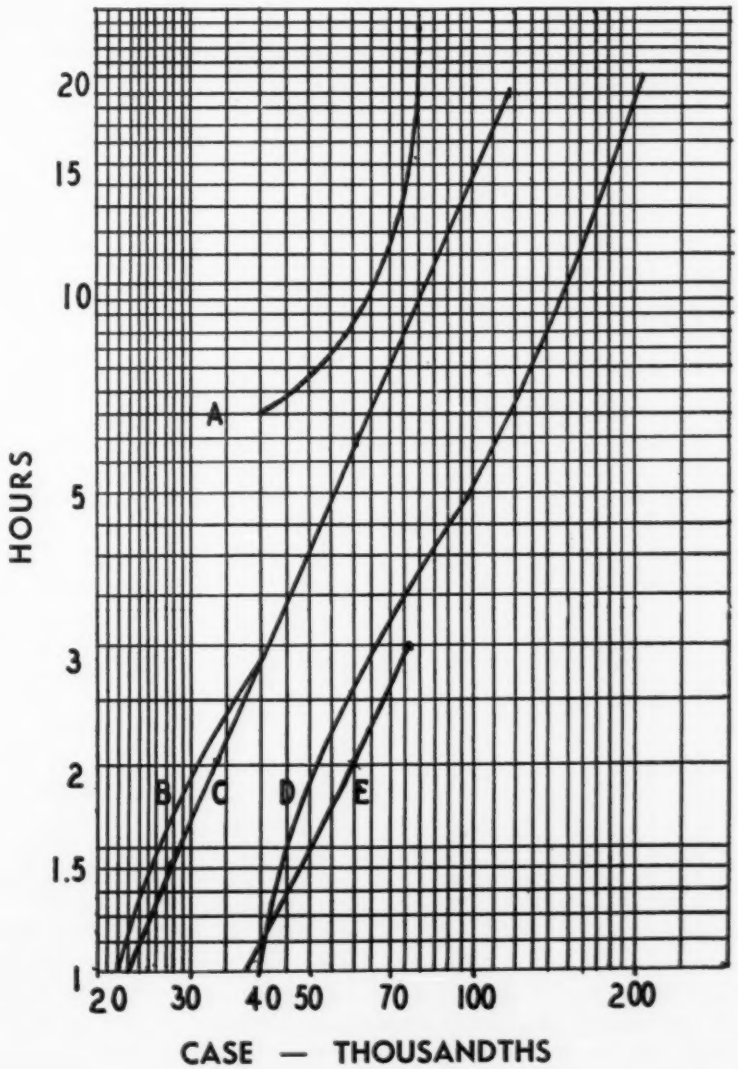


Fig. 5—Plot of carburizing data from various sources. (See text).

(4) *Iron Age*, May 22, 1958, pp. 123-125.
(5) *Metal Treating*, vol. X, no. 1, January-February, 1959, "High Temperature Carburizing" by H. N. Ipsen, p. 6.
(6) *Metal Progress*, October 1958, pp. 134-139.

METALLURGICAL RESEARCH DEVELOPS IMPROVED PRODUCTS THROUGH HEAT TREATING

By **HELEN HOOVER,** Research Metallurgist, Retired
Gunflint Lake
Grand Marais, Minn.

Editor's Note: *This article by Mrs. Hoover marks a departure from the usual type of article published in* METAL TREATING. *We believe that this article is valuable not only for the excellent technical information it contains but also because it illustrates the fact that the metallurgist should not be regarded as some intellectual "egg-head" researcher who should be put away in a laboratory. Instead he should be recognized as an important scientist who can and does make valuable contributions to many different departments of a plant.*

Also of unusual interest is the fact that in this particular case concerning the metallurgical research for the development of an austempered harrow disk, the research metallurgist was a woman. An understanding of Helen Hoover's occupational and educational background will shed some light on her success.

From 1927 to 1929 she attended Ohio University at Athens, Ohio; from 1930 to 1943 she read proof and edited for the Audit Bureau of Circulation; and from 1943 to 1945, when the war opened up free review courses, she studied at the University of Chicago and worked in a commercial testing laboratory—analyzing anything from steel to coal and doing some metallography.

Mrs. Hoover's interest in austempering stemmed from her next position in 1945 with the Ahlberg Bearing Company, where she had charge of the laboratory and all metallurgical and chemical work, particularly the shop where they were austempering bearing races. In 1948 she joined the research staff of the International Harvester Company, and in 1950, while running the metallography laboratory there, she took over and started the research concerning the disk. In 1952 she applied a test developed by Kahn and Imbembo in the laboratories of the Brooklyn Naval Shipyard to straight- and cross-rolled steel which showed that their differences could be quantitatively measured. Soon after, she found that austempering at a proper temperature would solve the disk problem.

In 1954, because of the illness of her husband, she resigned from the company and moved to the Canadian-border wilderness where she is presently residing and engaged primarily in writing. The complete and informative story of the development of the austempered disk appears below.

THE "DISK JOB" came into my life during the summer of 1950 in the form of a thick expanding file which lay on the polished table in the Metallurgical Section conference room of the International Harvester Company's Manufacturing Research Laboratories in Chicago.

The problem at hand, although it might be extended to disks of various sizes and types, concerned 16" harrow disks, made of BWG 12 C-1085 commercial-quality strip steel, either cross-rolled or straight-rolled. Cross-rolled was preferred because when such disks fractured in the field chips broke from the edge and the disk was often still usable. Straight-rolled disks failed by tearing along the rolling lines or by splitting off a section which put the disk immediately out of service. Although replacements were readily available, it was not hard to picture the reaction of a farmer to a series of disk failures in the middle of a busy day.

The use of cross-rolled steel was only a partial answer because supply did not meet demand. It was also more costly than straight-rolled strip. The question was: can a disk be made of straight-rolled steel which will equal the performance of a disk made of cross-rolled steel, other factors being reasonably equal? And in this question were implied two more, one of which must be answered: if so, how? and if not, why not?

Early Developments and Tests

The file contents—a collection of correspondence, laboratory reports, and clippings from the previous twenty years—offered no starting point. Disks, I learned, had been invented in 1847 and had come into general use at about the beginning of the Civil War. The concave disk appeared in 1877; and things had gone on with reasonable satisfaction until the advent of the tractor whose higher speeds put greater loads on the disks than had existed when harrows were horse-drawn. There followed the hardened-and-tempered disk, the alloy disk, and finally the cross-rolled disk.

The file also held complete information on the ball test, developed at International Harvester, in which a 1" hardened steel ball is forced through a ½" drilled and reamed hole in a disk, a disk section, or a sample of strip steel which is supported on a hardened ring of 3" diameter. (Fig. 1). The resulting fractures discriminate between straight- and cross-rolled strip steel by fracture type—straight-rolled breaking directionally along the rolling lines as in Fig. 11(1), and cross-rolled giving a random break similar to those in Fig. 11(2), (3),(4). However, this test gives no quantitative measurement of strength. A literature search revealed no reference to directionality in disks. References to

directionality in general were not pertinent to the start of the investigation.

A report of work previously completed at the research laboratory said only that microscopic examination, chemical analysis, an axial tension test, and a reverse bending fatigue test had shown no significant differences in the two materials and that results were inconclusive due to the limited and exploratory nature of the work.

Interviews with everyone in or out of the company who might conceivably supply information on disks or directionality brought many offers of assistance, no suggestions as to how to proceed, and various opinions, mostly neutral or discouraging. Plainly my way lay along an uncharted, and probably rough, route.

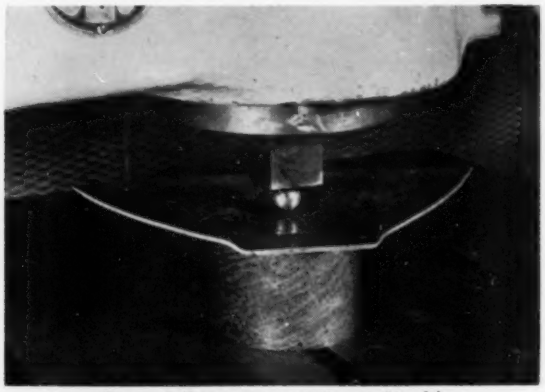


Fig. 1—Ball test setup on testing machine.[1]

So many people believed that the answer lay in axial tension or reverse bending fatigue tests that a recheck was mandatory although I felt that the testing would only serve to eliminate them. Disks, which are mounted through a centerhole and loaded in service by forward movement through and against the earth and by sudden shock when they strike a stone or the harrow gang bounces over an obstruction, fail neither in tension nor in reverse bending. It seemed to me that both the slow tearing and the sudden breakage were caused by impact, the former by many small shocks and the latter by a single severe one. If this were true, notch sensitivity was involved and Izod or Charpy impact tests might be helpful. At least, they should come nearer to applying stresses related to those which caused failure in the field. However, special low-load equipment would have to be built because of the thin-gauge strip, and any such tests not only would be non-standard but probably would be very sensitive to any machining variations because of their small cross-section. The starting point decided on was a comprehensive recheck of the work spot-checked in the preliminary report.

The material for the tests consisted of straight- and cross-rolled BWG 9 C-1085 commercial-quality strip steel, supplied by the Ingersoll Steel Division of Borg-Warner Corporation.

Preparation for New Tests

Throughout the testing, specimens cut parallel to the strip length and to the rolling or final-rolling direction were designated as "parallel;" those taken at right angles, as "transverse." Samples from edge and center sections were taken for chemical analysis. Rectangles 6" x 6" were taken for ball testing. Parallel and transverse specimens for tension and fatigue testing were laid out, covering not only both sides of each strip but also edge and center locations in each half. Parallel and transverse specimens for microscopic examination were taken from edge and center locations, with extra samples for study of inclusions, these being cut parallel to the strip length and polished on a plane parallel to the surfaces of the strip. Special samples were taken for cathodic etching and magnetometric study.

The hardness requirement for the heat treated disks under consideration was Rockwell C 36-44. A heat treatment for mechanical-test specimens, designed to produce a tempered martensitic structure with hardness in the upper part of the required range and designated

[1] All illustrations in this article are courtesy of *International Harvester Company*.

Table 1

AVERAGE AXIAL TENSION AND REVERSE BENDING FATIGUE TEST; PROPERTIES OF HARDENED-AND-TEMPERED C-1085 STRIP STEEL.

Property	Straight-Rolled			Cross-Rolled		
	Parallel	Transverse	Average	Parallel	Transverse	Average
Axial Tension Test						
Yield Strength, psi	164 100	165 400	164 800	167 700	175 300	171 500
Tensile Strength, psi	201 500	203 500	202 500	206 600	206 100	206 300
Yield/Tensile	0.81	0.81	0.81	0.81	0.85	0.83
Elongation in 2 in., %	9.0	7.5	8.0	7.0	6.5	7.0
Reverse Bending Fatigue Test						
Applied Stress at Runout, 10^7 cycles., lbs.	73 000	71 500	72 200	69 200	72 400	70 800

Note: Parallel and Transverse refer to final rolling direction (length of strip).

"martemper" throughout the testing, was as follows:

Austenitize in neutral salt, 1575° F for 10 minutes;
Quench in neutral salt, 350° F for 2 minutes;
Air cool; wash; dry;
Furnace temper, 820° F for 1 hour.

First Results

Surface inspection revealed no gross defects. Chemical composition proved to be within AISI allowable limits. The ball test differentiated between the two types of rolling in both the as-rolled and heat treated conditions. The inclusion examination (Fig. 2) revealed that the nonmetallics in the straight-rolled strip were strongly aligned with the rolling, while those in the cross-rolled showed little orientation with either the primary or final rolling. The other tests and studies, (Table I summarizes results of tension and fatigue tests) revealed no significant differences between either the types of steel or the locations in the strip.

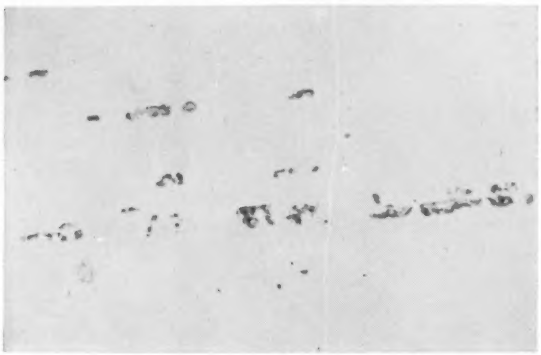
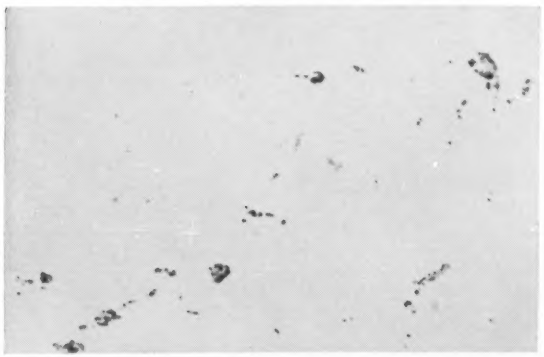


Fig. 2—Nonmetallic inclusions, C-1085 commercial-quality strip steel. Unetched; 100x.

(a) Discontinuous, ribbonlike forms in straight-rolled strip on longitudinal plane parallel to surfaces of strip.



(b) Irregular, pancaked forms in cross-rolled strip, similar plane.

The first year's work had eliminated axial tension and reverse bending fatigue tests, along with cathodic etching and the magnetometer, as being practical methods of measuring directional strength in the type of material tested; and it had brought the preferred orientation of the inclusions in the straight-rolled strip into prominence.

There were some strong opinions that the elongated inclusions were causing the directionality of the straight-rolled disk field failures and that nothing could be done about it. Although several failures in the completed mechanical tests could be laid definitely to the effect of serious nonmetallic segregation at the point of the start of failure, it did not seem to me and to some others that the inclusions should necessarily be held solely accountable for the problem. There was also the matter of preferred crystal orientation.

Table II

AVERAGE NAVY TEAR TEST PROPERTIES OF HARDENED-AND-TEMPERED C-1085 STRIP STEEL.

Angle of Specimen, deg.*	Maximum Load, lbs.		Work Absorbed to Fracture, ft-lbs.		Extension, in.	
	Straight-rolled	Cross-rolled	Straight-rolled	Cross-rolled	Straight-rolled	Cross-rolled
0	20 150	18 100	98.0	75.0	0.1110	0.0970
22.5	19 800	17 900	85.5	74.0	0.1025	0.0870
45	18 300	16 300	64.0	48.0	0.0825	0.0705
67.5	15 450	16 700	45.0	51.5	0.0695	0.0735
90	14 450	16 900	45.0	64.5	0.0755	0.0905
Average	17 650	17 200	67.5	62.0	0.0880	0.0835

*In relation to final rolling direction (length of strip).

I rechecked my extracts from the literature. Jevons[1] had stated that preferred orientation of crystalline structure and directional distribution of nonmetallic inclusions are causes of directional behavior in metal. According to Heindlhofer[2], serious deviation from isotropy exists in processed metals especially after considerable reduction in thickness; and this lack of isotropy in elastic properties was due to the texture which arises, largely in drawing or rolling, where the grains are given a more or less common orientation. Bruggeman[3] had found that the elastic properties of rolled multi-crystalline metals may resemble those of single crystals which have definite directionality.

From these conclusions, it seemed reasonable to expect rolled strip steel to have different elastic constants and physical properties in different directions in relation to rolling, and that these differences should be more marked in straight-rolled strip than in cross-rolled. But we could not progress until we could quantitatively measure any existing differences in directional strength. We needed some test of greater sensitivity.

Still aware of the difficulties attendant upon using impact tests, I went through the file of early material again and came upon an account of the Navy tear test[4], developed by Kahn and Imbembo at the U. S. Naval Shipyard in Brooklyn, as a means of evaluating transition from shear to cleavage failure in ship plate. Evidently someone before me had considered trying a

(1) J. D. Jevons, *The Metallurgy of Deep Drawing and Pressing*, 1940.

(2) K. Heindlhofer, *Evaluation of Residual Stress*, 1948.

(3) D. A. G. Bruggeman, "Elastic Anisotropy in Iron," *Naturwissenschaften*, vol. 19, 1931.

(4) N. A. Kahn and E. A. Imbembo, "A Method of Evaluating Transition from Shear to Cleavage Failure in Ship Plate and Its Correlation with Large-Scale Plate Tests," *Welding Journal*, vol. 27, April, 1948.

new test in connection with disk failures. A search brought to light three more papers on the test[5,6,7], one of which dealt with notch sensitivity in steel as evaluated by the tear test. This test might well be our measuring tool.

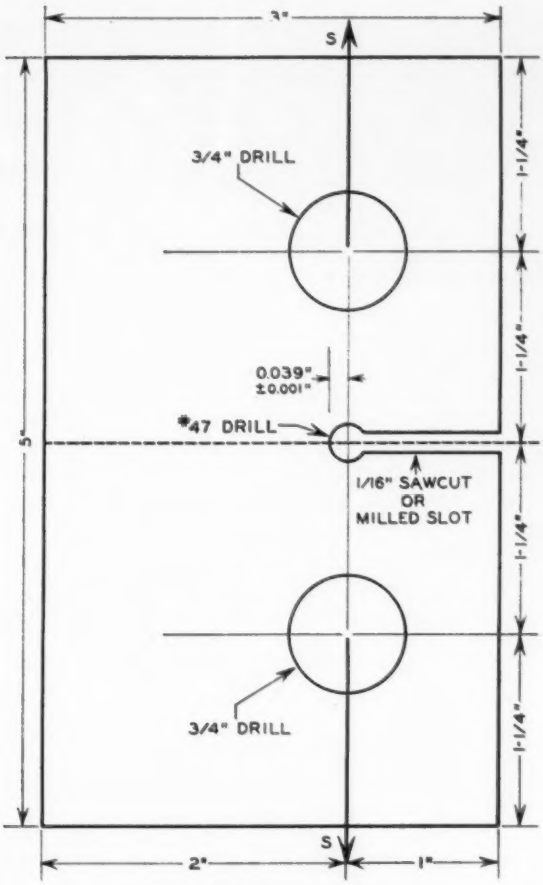


Fig. 3—Navy tear test specimen.

Use of the Navy Tear Test

The Navy tear test specimen (Fig. 3) was essentially a type of notch-tensile specimen with the base of the keyhole notch offset .039" from the line of loading. We prepared specimens, parallel and transverse, covering edge and center locations. Some were reserved for testing as-rolled, and the balance were heat treated according to the standard previously set up. Tests were run on a 60,000-lb. testing machine, with PD-1M deflectometer and automatic stress-strain recorder. (Fig. 4). Specimens were loaded in static tension at the rate of 0.10" per minute.

(5) Kahn and Imbembo, "Notch Sensitivity of Ship Plate:—Correlation of Laboratory-Scale Tests with Large-Scale Plate Tests," Symposium on *Deformation of Metals as Related to Forming and Service*, Am. Soc. Testing Mats., 1948. (Issued as separate publication ASTM STP No. 87.)

(6) Kahn and Imbembo, "Notch Sensitivity of Steel Evaluated by Tear Test," *Welding Journal*, vol. 28, 1949.

(7) Kahn and Imbembo, "Further Study of Navy Tear Test," *Welding Journal*, vol. 29, 1950.

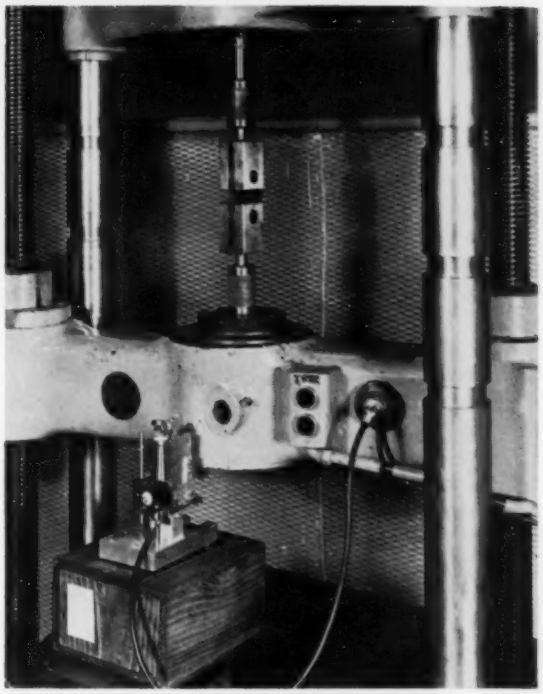


Fig. 4—Navy tear test setup on testing machine, with deflectometer in place.

The autographic record from these tests was a right triangle with the pen forming the hypotenuse as it rose with increasing load. The vertical drop-off after fracture formed the altitude which was a measure of maximum load in pounds. The base was the extension in inches. The area inside the triangle was the work absorbed to fracture in inch-pounds. As all fractures were of the "instantaneous" type and no tearing was observed, the maximum load to initiate fracture was essentially the total load to initiate and complete fracture; and the extension was a measure of elasticity.

A glance at the results showed clearly that the straight-rolled strip had much higher tear-test properties in the direction of rolling than transverse to it; that the cross-rolled showed considerably less variance; and that the average for both directions was much the same in both types of strip. We now had our test for measuring directional strength. The earlier tension and fatigue tests had failed to show the differences because apparently they had measured average properties.

An Angular Test Devised

An interested colleague with whom I was discussing the results, noted that if they were graphed in polar form the pattern would be that of two ovals, with the straight-rolled longer and narrower than the cross-rolled. Commenting that we could not assume an oval with only two axes and that we might be able to determine the strength pattern throughout the strip, I hurried away to design a plan for sampling at 22.5 degree angles to the rolling (Fig. 5).

The test results far exceeded expectations. The heat treated straight-rolled angled specimens, instead of fracturing at right angles to the line of loading as was expected and as had been the case with the specimens cut parallel and transverse, broke along the rolling lines! (Fig. 6). All cross-rolled specimens broke at right angles to loading.

Apparently the tear test produced an effect related to that which caused failure in the field because, in failing, the specimens showed somewhat the same behavior as disks. Again the argument was put forward that the directional tear-test and field failures were caused by the influence of the inclusions, which started the fracture along the rolling lines no matter how the load was applied, and that no amount of testing or knowledge could remove the inclusions.

The stress analysis department was called in to throw light on the mechanism of the failure of the tear-test specimen. A photoelastic fringe pattern and a graph of the two principal stresses at the base of the notch are shown in (Figs. 8 and 9).

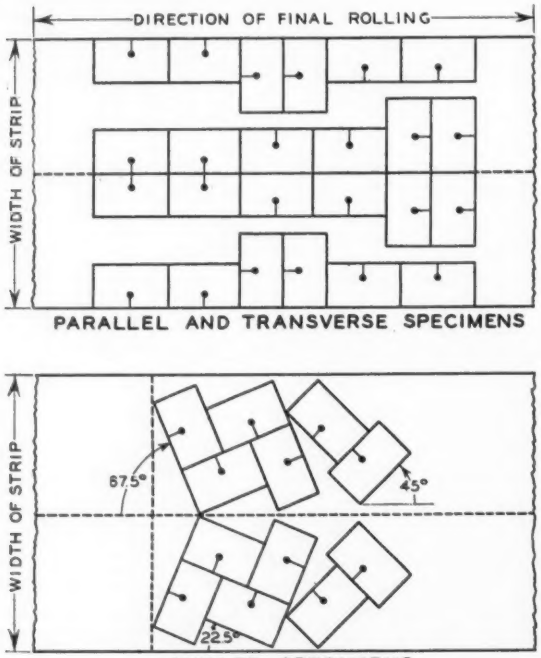
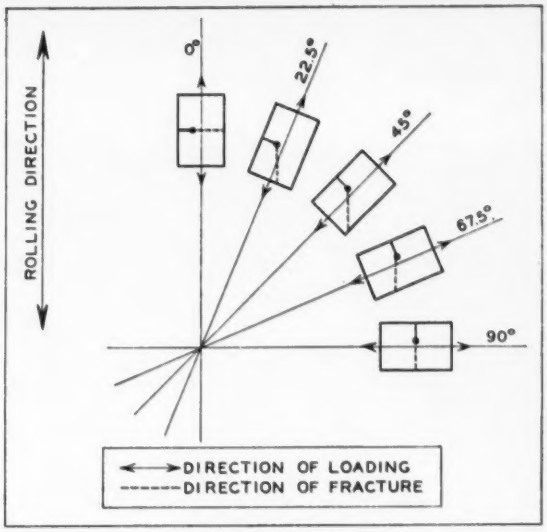


Fig. 5—Navy tear test sampling plan.

The stress is highest in a small angular range at the base of the notch and decreases rapidly to near zero at approximately 0.099" inward and remains very small. Slight yielding at the notch base would be inhibited by the biaxiality just beyond. The load would rise to a maximum and produce abrupt fracture as was the case with the specimens tested, and it might be assumed to be the case in certain disk failures. Only one stress is present at the notch base, and fracture must start at right angles to the loading and so proceed into the biaxial region where, lacking a dominant stress

Fig. 6—Directions of rolling, sampling, loading, and fracture in Navy tear test, straight-rolled C-1085 strip steel, hardened-and-tempered.



direction, the break would be expected to proceed in the weakest direction.

This seemed to refute the argument that the influence of the directionally-orientated inclusions was strong enough to cause the straight-rolled fracture to start at an angle in the direction of rolling. True, the fracture, once started, followed the rolling lines; but there was nothing to indicate that crystalline orientation might not exert an influence as strong as or even stronger than the nonmetallics.

Examination of the Results

Examination of the test results (Table II) and their graphs (Fig. 7) was more illuminating. Both maximum load and work absorbed to fracture increased with rolling extension. Cross-rolling had not eliminated directionality but had counteracted its bad effects by producing a secondary directionality at right angles to that introduced by the first rolling. Since the two rolling directions of the cross-rolled were indicated by the strength distribution on the polar graph, and since the nonmetallics of the cross-rolled had not appeared to be orientated in the two rolling directions, it seemed that here was evidence that preferred crystalline orientation had a stronger influence than nonmetallics in producing the directionality we had measured.

If this were true, the directionality might be overcome. Directional strength differences had not shown in tear tests of parallel and transverse unhardened straight-rolled strip, but they were marked after hardening and tempering. Therefore, hardening and tempering did not remove the presumed directional effect of crystalline orientation but increased it. What would some other heat treatment do? Would a microstructure other than the tempered martensite now be considered best? I could see no other approach but, with only tenuous reasonings based on the results of a few tests,

I was in no position to ask to embark on a full-scale study of heat treating methods for disks.

The Use of Field Tests

Twenty-eight disks, of which half were straight-rolled and half were cross-rolled, had been field tested and supplied by the IH Rock Falls Works for intensive comparative study. A direct comparison was invalidated at the start by thickness measurements which showed the cross-rolled disks to be BWG 11 and the straight-rolled to be the thinner BWG 12 specified. The investigation turned into an immensely complicated study because inspection of stamping and damage revealed that the straight-rolled disks were from three heats of which two showed failures and the third did not.

Diameter, concavity, and weight were recorded. The disks were inspected by Zyglo and analyzed chemically. Ball tests were made and microscopic examination of edge sections and inside microstructures at and away from points of failure.

Navy tear tests, whose use had been in doubt because of the curvature of the specimens cut from the disks, gave the same general performance that they had with the flat strip previously tested. Although there was some effect from the curvature, the specimens flattened out at relatively low loading and the load then rose to its maximum. The distortion of the results was not serious enough to invalidate the results, but there was no way accurately to compute the effect of the curvature. These tests showed the expected directional fracture of the angled specimens from the straight-rolled disks and separated the straight-rolled disks both by performance and by heat, although there was some overlapping of individual results from these groups.

As soon as it was certain that the Navy tear test could be used on finished disks, arrangements were made with the Hamilton Works of the International Harvester Company of Canada and their supplier, the Steel Company of Canada, to send for comparative study some finished disks, along with samples of the straight-rolled strip from which the disks were made.

The strip arrived quickly. While its study progressed, I pored over the mass of data accumulated from the examination of the disks from the field tests. Of all the results, only those from the tear tests could be related to the type of rolling and the failures. Precisely why the straight-rolled failures occurred in their directional manner and what could be done about it remained mysterious.

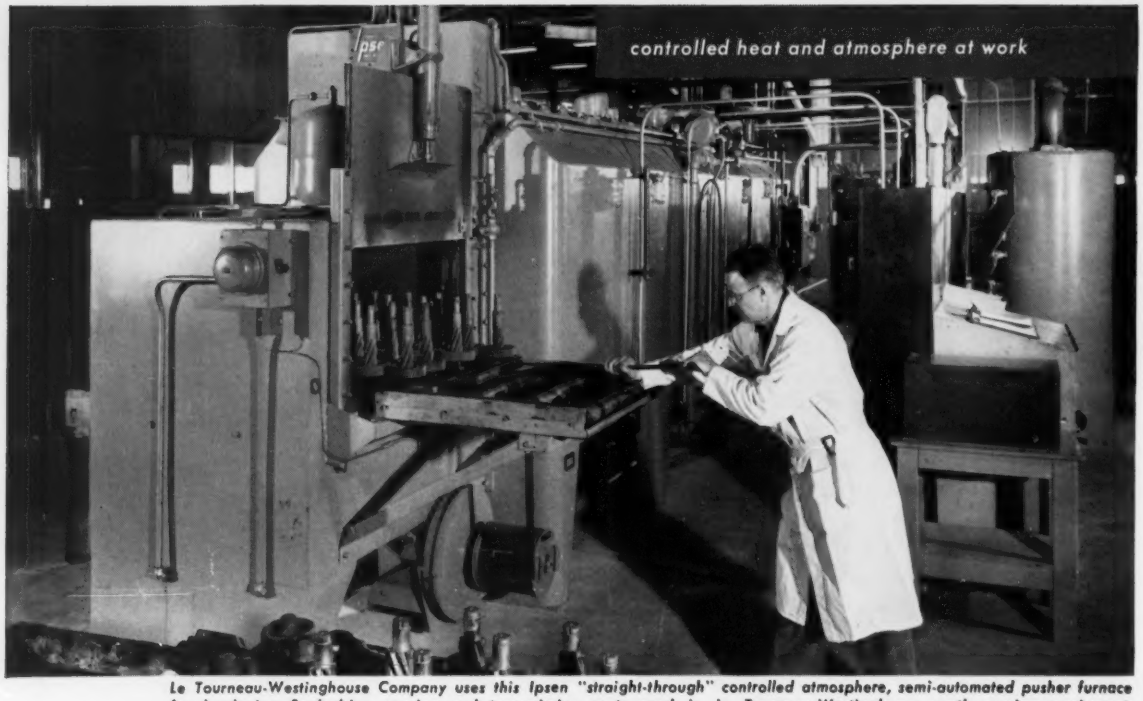
(Continued on page 40)

Table III
SUMMARY OF TEST RESULTS, HEAT-TREATED, STRAIGHT-ROLLED C-1085 STRIP STEEL (AUSTEMPERED: 750°-1150°F).

Property	"Martemper" (hard-temp)	Austemper					
		750°F.	850°F.	950°F.	1050°F.	1100°F.	1150°F.
Fracture	Directional	All nondirectional					
Navy Tear Test							
Maximum Load, lbs/in. Parallel (max.)	118 700	136 700	122 000	116 000	106 900	94 000	90 600
Transverse (min.)	93 200	108 800	106 200	98 600	92 400	87 300	80 100
Average*	105 100	124 500	114 000	108 300	100 100	91 300	84 200
Work Absorbed to Fracture, ft-lbs/in. Parallel (max.)	454	747	598	594	622	503	482
Transverse (min.)	248	372	390	363	334	393	354
Average*	334	593	481	466	484	450	432
Extension, in. Parallel (max.)	0.087	0.114	0.106	0.106	0.118	0.106	0.107
Transverse (min.)	0.062	0.080	0.082	0.083	0.078	0.094	0.091
Average*	0.072	0.102	0.093	0.092	0.097	0.099	0.102
Axial Tension Test							
Yield Strength, psi	178 600	160 000	148 200	117 200	88 400	86 100	78 000
Tensile Strength, psi	209 000	198 400	193 300	172 200	150 000	147 600	144 700
Yield/Tensile	0.85	0.81	0.77	0.68	0.59	0.58	0.54
Elongation in 2 in., %	8.0	10.5	10.0	11.0	13.0	13.0	11.0

*Average of 5 angular positions.

Note: Parallel and Transverse refer to final rolling direction (length of strip).



Le Tourneau-Westinghouse Company uses this Ipsen "straight-through" controlled atmosphere, semi-automated pusher furnace for hardening final drive gearing and transmission parts used in Le Tourneau-Westinghouse earth moving equipment.

"...we've increased production 25% and reduced costs with our Ipsen pusher heat treating units."

Le Tourneau-Westinghouse Company, Peoria, Illinois

Harold C. Stone is Chief Metallurgist of Le Tourneau-Westinghouse Company, Peoria, Illinois, one of America's leading producers of earth moving equipment. In the following interview, Mr. Stone tells why he is well satisfied with his Ipsen controlled atmosphere pusher heat treating equipment.

Q. What type of work do you run in your Ipsen "straight-through" controlled atmosphere heat treating unit?

A. We use our Ipsen pusher equipment for the controlled atmosphere hardening of final drive gearing, transmission parts, and other parts used in our Le Tourneau-Westinghouse earth moving equipment. Every 15 minutes the furnace receives a 200-lb. charge which remains in the furnace 90 minutes, and in the quench 10 minutes. If necessary, we can increase our charges to 500 lbs. and heat treat 2000 lbs. per hour.

Q. Have you been able to increase production with your Ipsen equipment?

A. We have achieved an approximate 25% increase with our Ipsen unit (as compared with the four salt pots it replaced). Part of this improvement is due to the fact that our work is pushed through the furnace work chambers, and quench, automatically. This, of course, is faster than would be possible if it had to be handled by our operators.

Q. What about your operating or production costs?

A. Fuel costs have definitely been reduced. Gas consumption with our Ipsen unit (including the generator) is less than 1,000 cfh...as compared with a total of 2,000 cfh for the four pot furnaces which turn out less work. Straightening, which was formerly required on about 80% of our parts with long shafts, has been virtually eliminated. And sand blasting is no longer necessary.

Q. What do you think of the automatic quench feature of your Ipsen equipment?

A. We like it because we can set the temperature of the quenching medium and maintain it. As a result, we obtain better quality and less distortion. We save labor by quenching batches instead of individual pieces.

Q. What about maintenance?

A. We haven't had any maintenance to speak of...only routine and preventive maintenance.

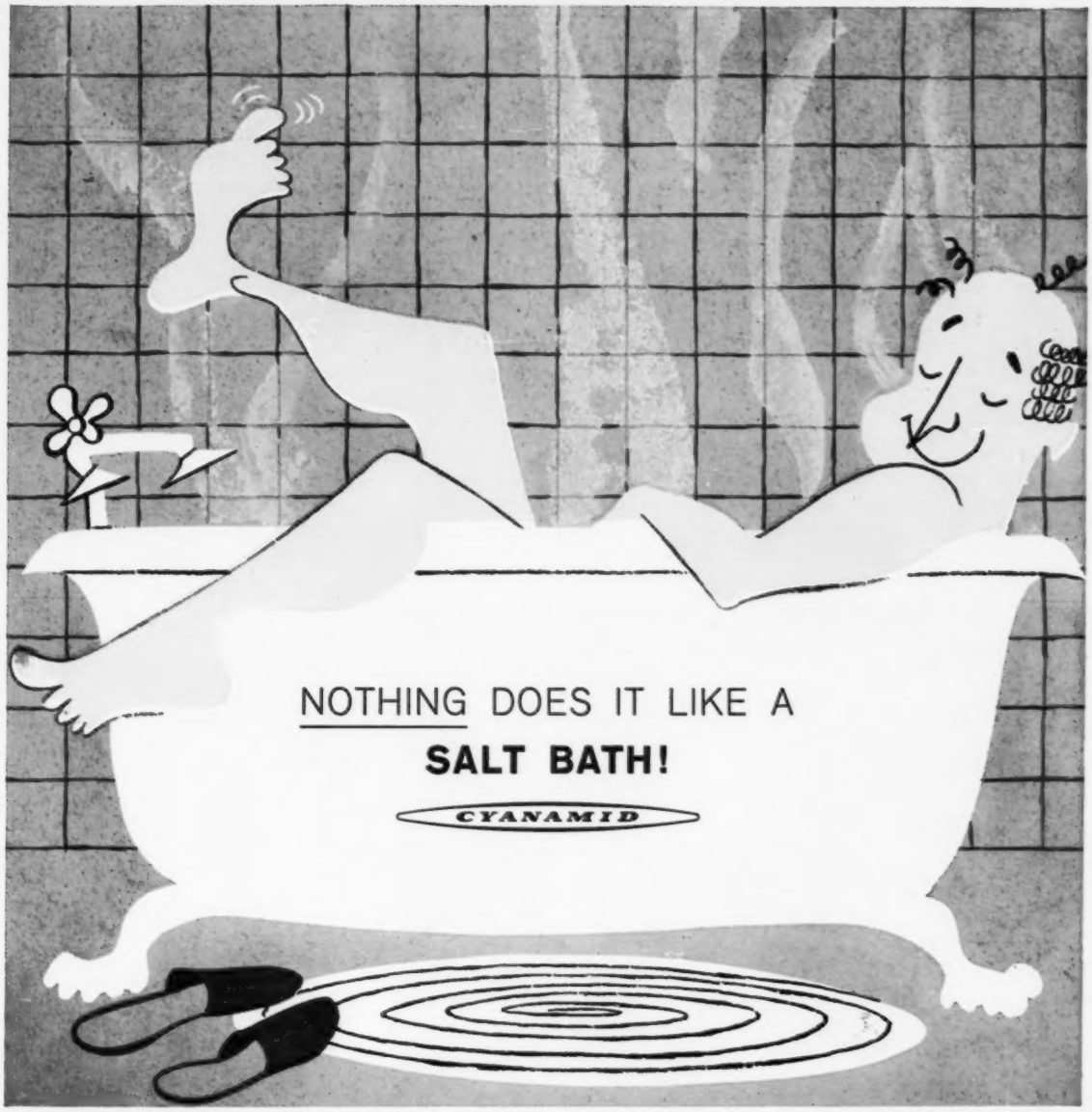
Q. Have your men commented on Ipsen equipment?

A. Yes. Our heat treat foreman, Mr. Waldo Dirkes, says it's one of the nicest pieces of equipment we have. He says the pusher furnace is simple to operate and certainly easy to keep clean.

Ask for your copy of a brochure describing the type of Ipsen equipment used by Le Tourneau-Westinghouse.

AUTOMATIC Ipsen HEAT TREATING UNITS

IPSEN INDUSTRIES, INC. • 733 S. MAIN STREET • ROCKFORD, ILLINOIS



There are other ways to heat treat metals, but nothing quite compares in *deep-down, over-all, satisfying* results with a Salt Bath.

For one thing, salt furnaces heat work faster and more evenly because temperatures are uniform throughout the bath. Too, salt baths *eliminate* scaling and decarburization without the use of special atmospheres . . . even from bath to quench since a thin protective layer covers the metal. Partial immersion of the work also allows selective heating.

With all of this, initial *costs*, operating costs and maintenance costs are low. Long pot life means less down time; high thermal efficiency means low operating expense. Mechanization saves labor costs, increases production.

Why not check with your *Process Chemicals* salesman and learn of the "engineered advantages" of Cyanamid's highest quality heat treating salts—or drop us a line. Then, put your heat treating, case hardening and carburization jobs into a bath filled with Cyanamid Salts, settle back and enjoy the satisfaction of a job well done.

AEROCARB® — Carburizing Compounds
AEROCASE®—Case Hardening Compounds
AEROHEAT®—Heat Treating Salts

CYANAMID

AMERICAN CYANAMID COMPANY
PROCESS CHEMICALS DEPARTMENT
30 Rockefeller Plaza, New York 20, New York
In Canada: Cyanamid of Canada Limited, Toronto and Montreal

NEWS TO HEAT TREATERS...

NEW VERTICAL DROP-BOTTOM FURNACE

The J. W. Rex Company, Lansdale, Pa., has just completed the enlargement of their new installation of a vertical drop-bottom traveling furnace for hardening and tempering.

The equipment was specifically designed for handling of large cylindrical, tubular, and rectangular sections. It will handle loads such as missile solid propellent engine chambers, liquid fuel chambers and tanks, nozzles, venturis, jato tanks and similar components. Hardening, tempering, and quenching facilities are all combined in one installation.

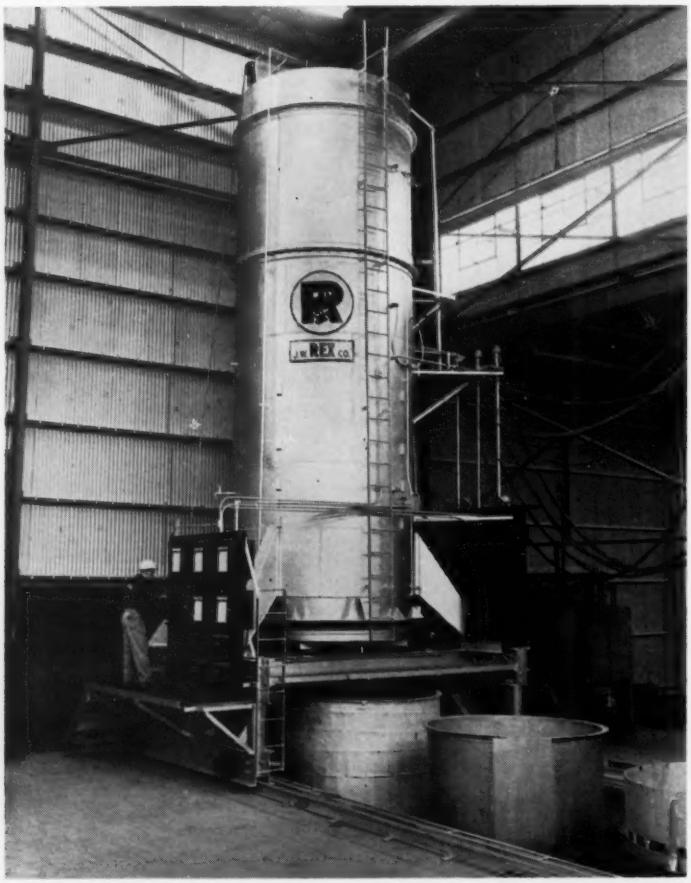
Hardening is done in a vertical, electrically-heated atmosphere furnace equipped with a 4000 cfh Lindberg Hyen generator which supplies the protective endothermic atmosphere. Maximum furnace temperature is 1950°F, and the effective work load accommodated is 22' long by 71" in diameter. The complete body of the furnace is sealed for atmosphere use. Carbon control is by dew point; an Alnor unit samples at the generator and at the furnace.

Heat is supplied by Nichrome elements mounted on the refractory brick in tiers, and 470 kw is provided in four zones of control. Temperature in the four heating zones is controlled by four Leeds & Northrup strip-chart recorder-controllers. A fifth L&N instrument—a multipoint strip-chart recorder—serves as a check on the other four units.

The furnace travels above the furnace pit on a gantry driven by an electric motor and reduction gear train. In this way the furnace can be moved back and forth to position it over the loading station, quenching tanks, and tempering furnace. The furnace pit itself contains the loading station, water tank, and salt tank. The loading station is also suitable for forced-air quenching. The marquenching salt tank is of the nitrite-nitrate type, is heated by gas radiant tubes, and provides an operating temperature of 800°F maximum.

A tempering furnace serves as auxiliary equipment for the hardening cycle. The unit is heated by electric ribbons of 170 kw capacity and has a maximum temperature of 1500°F. It is positioned in the pit to allow the hardening furnace to travel over the top, thus enabling parts to be pre-heated and raised directly into the hardening furnace.

For further information circle No. 1



J. W. Rex Co.'s vertical drop-bottom hardening furnace travels above the furnace pit on a gantry and can be positioned over the loading station, quenching tanks, and tempering furnace.

HEAT TREATING FORUM

During the recent Western Metal Exposition and Congress which was held in Los Angeles during the week of March sixteenth, one of the morning technical sessions was devoted to a forum on "Steel Heat Treating . . . Carbon Control."

The moderator was Dr. Leo Schapiro, Douglas Aircraft Co., and the participants were Norbert Koebel, Lindberg Engineering Co.; O. E. Cullen, Surface Combustion Co.; W. R. Varney, Calmec Mfg. Co.; R. H. Lundquist, California-Doran Heat Treating Co.; Morris Tiktinsky, Lockheed Aircraft Corp.; and J. C. White, North American Aviation, Inc.

NEW BRIGHT HARDENING DEPARTMENT

Mr. Charles H. Hewitt, President of The Dayton Forging and Heat Treating Co., Dayton, Ohio, has announced a new addition to his plant. A new building was built 30' by 160' which houses their new bright hardening department.

The photograph illustrates part of the new equipment, and a list of the entire equipment in the department is as follows:

1 Lindberg Car type tempering furnace, working capacity, 8' x 9' x 12' 6";

1 Lindberg Pit type tempering furnace, working capacity 4' x 6';

1 Lindberg Bright tempering furnace, work capacity 24" x 30" x 48";

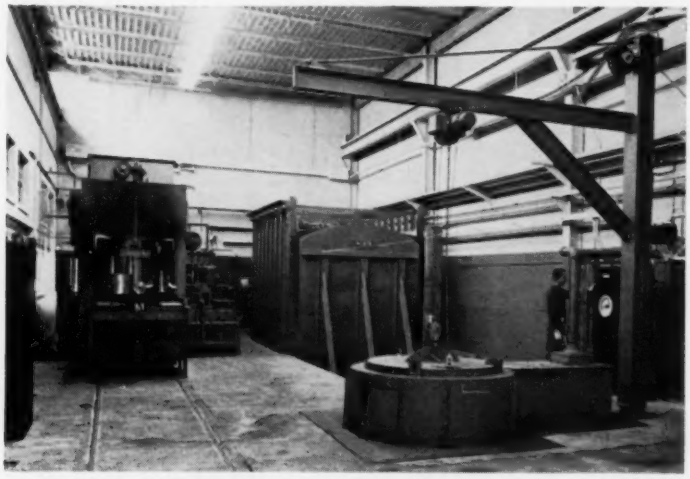
2 Lindberg Bright hardening furnaces, work capacity 24" x 30" x 48"; oil capacity 1200 gal.;

1 Lindberg Bright hardening furnace, sixe 36" x 48" x 72", oil capacity, 3550 gal.

1 Blakeslee Wash Machine, work capacity 3' x 4' x 7'.

1 Endothermic Generator 1500 cfh; 1 Endothermic Generator 3000 cfh; and 1 Exothermic Generator 800 cfh.

For further information circle No. 2



NEW IHEA OVEN DIVISION

The Industrial Heating Equipment Association has formed an Industrial Oven Division. Representatives of leading oven manufacturing firms attended the 30th Annual Winter Meeting of the Association in January and determined to affiliate their firms in the new IHEA group.

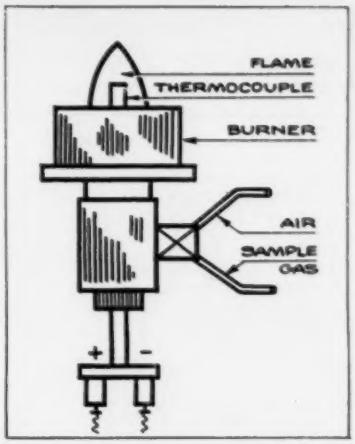
The organization of IHEA is now composed of four groups—Furnace, Induction and Dielectric, Combustion, and the newly-created Oven Division—the latter composed of twelve manufacturing firms of which nine are new IHEA members. Estimates indicate that the IHEA oven group produces in excess of 60 per cent of the nation's industrial ovens.

Mr. Robert Baker of the R. C. Mahon Co. was elected Chairman, and Mr. Chester J. Schmidt of the J. O. Ross Engineering Co., secretary.

CARBON POTENTIAL CONTROL

Rolock Incorporated of Fairfield, Conn., has developed a new type of automatic carbon potential controller for use with endothermic gas generators serving controlled atmosphere heat treating and carburizing furnaces. The same basic equipment and principles of operation could be adapted to related control requirements for any burnable gas. The equipment is marketed under the trade name "Rolock"—and is compact and ready for installation.

This new concept in automatic carbon control uses new control principles by continuously measuring the temperature at a single point inside a small flame and burning a sample of the gas under constant pressure and with constant volume. To each carbon potential of the sample gas there is a corresponding flame temperature to which the controller can respond, thus providing better control accuracy.

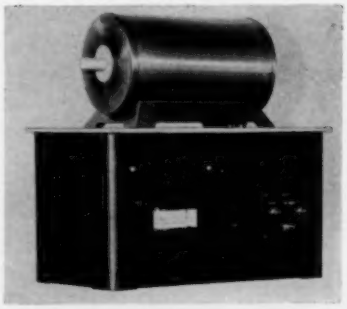


The unit is said to assure constant automatic monitoring and immediate adjustment when in closed control circuit with furnaces or gas generators, provided that the generators themselves are capable of holding carbon level within a reasonable range.

For further information circle No. 3

HIGH-TEMPERATURE FURNACE

Lucifer Furnaces, Inc., Neshaminy, Pa., announces the addition of a new series of electric heat treating furnaces. The Series 6055 is



made in six standard models with heat ranges to 3000° F. The new Kanthal Super Element is used in all 6055 models.

For further information circle No. 4

(Continued on page 36)

THE APPRENTICE CORNER

Editor's Note: This is the final article on this topic of a series which has been published in the past several issues. They have been abstracted from the book *Injury in Ground Surfaces* by Dr. L. P. Tarasov of the Norton Company Research Laboratories with the kind permission of the publisher, the Norton Company, Worcester, Mass., who also furnished the photographs.

Nature of Burn

As has been mentioned earlier in this series, burn comprises not only the visible discoloration resulting from overheating the surface by grinding, but also the metallurgical changes that may accompany this excessive heating. It is the metallurgical changes that are really important, visible burn serving primarily to show that such changes may have occurred.

Metallurgical burn is limited to steels capable of being hardened by quenching and softened by tempering. Cemented carbides and cast alloys of the Stellite type do not change in room-temperature hardness as a result of exposure to high temperatures, and are not subject to metallurgical burn in grinding.

Effect of Burn on Hardness

Hardness changes in a ground surface resulting from burn can be easily measured on a Tukon Tester. This instrument, resembling a Rockwell Hardness Tester in construction, applies an extremely light load to a specially-shaped diamond indenter, and the length of the resulting indentation in the specimen being tested is measured accurately on a high-power microscope. The Knoop hardness number is calculated from the length of the indentation and it comes out to be roughly the same as the Brinell hardness number. The shape of the indentation is that of a highly elongated diamond or parallelogram, whose width is one-seventh the length.

When a 100-gram load is used in determining the Knoop hardness of hard steel, the indentation is somewhat under 0.002" in length and it is only one-thirtieth as deep, or slightly over half a ten-thousandth of an inch. Since a ground surface that has been softened by burning is likely to be softened considerably deeper than this, the drop in surface hardness can be easily measured. It should be noted that a very smooth surface is required for Knoop indentations, so that a ground surface should be polished lightly before it is indented.

A great deal more information about burn can be gained by preparing a polished cross-section through the burned surface. The variation of hardness with depth below the surface can then be measured accurately. Some hardness curves, obtained in this manner on specimens purposely burned by grinding with too hard a wheel, are shown in Fig. 1. The depth of softening is seen to increase with an increase in the *unit downfeed*, or the downfeed per completed crossfeed, which is given next to each curve in terms of mils or thousandths of an inch. With the greatest unit downfeed, which was three mils, so much heat was generated that the surface temperature of the steel exceeded the hardening temperature and a layer of freshly-hardened steel was formed to a depth of about a tenth of a mil; the presence of this layer is indicated by the dotted portion of the curve.

Detection of Burn by Etching

From a practical point of view, the detection of burn by means of hardness changes is usually much too laborious. Fortunately, there is a much simpler and more rapid way of detecting burn and of estimating its severity. This is to etch the ground surface and to observe the resulting discoloration. For the

(Continued on page 30)

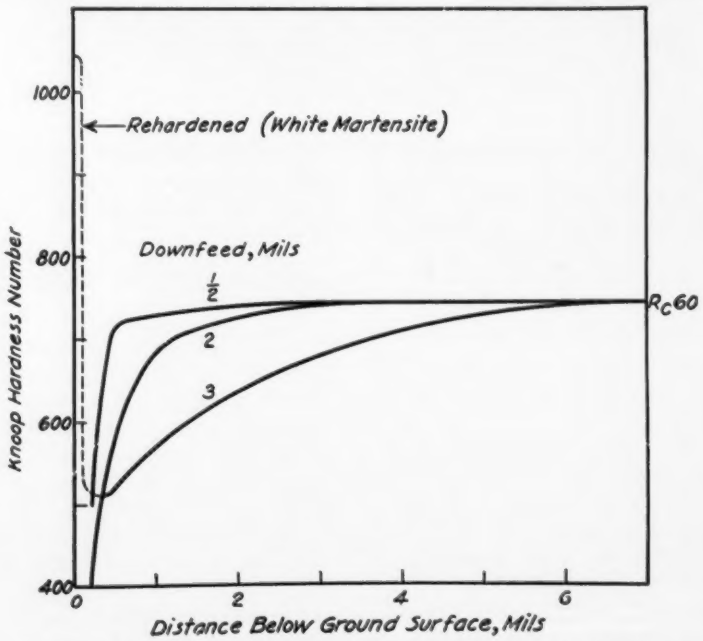
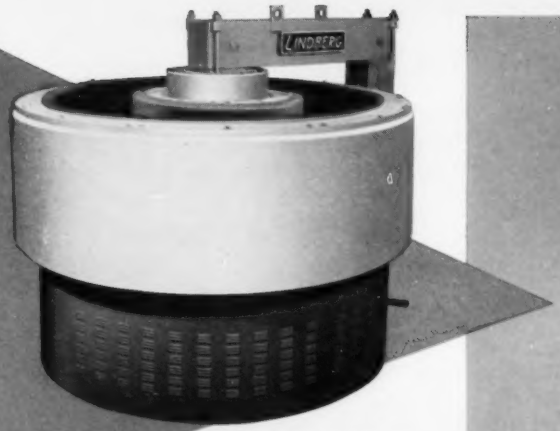


Fig. 1—Variation of hardness with depth below ground surface in hardened tool steel ground with too hard a wheel. Curves corresponding to downfeeds of ½ and 2 mils per completed crossfeed show surface softening, while the remaining curve shows both surface rehardening and sub-surface softening. One mil equals a thousandth of an inch.

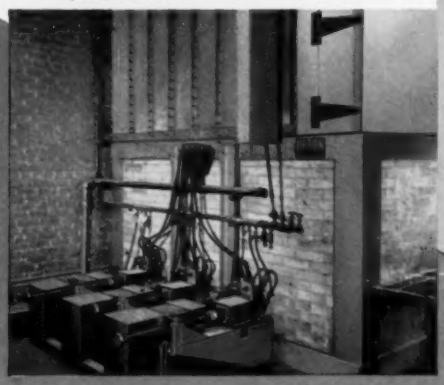
Two good names join . . .

LINDBERG UPTON

for better service in salt bath furnaces



Lindberg Induct-O-Ring, first electric production salt bath furnace, that can be shut down overnight and regain operating temperature quickly. Rotary action provides positive quality control.



Upton aluminum dip brazing Salt Bath Furnace featuring Continuing Graphite Electrodes. Installation in plant manufacturing industrial heat exchangers. Note insulated chamber over salt bath.

This line of Upton Salt Bath Furnaces, in use in a commercial heat treating plant, handles all types of steel heat treating including high-speed steel tools and parts.

A complete line of high and low temperature salt bath furnaces for any production, pilot plant or laboratory use is now available from Lindberg. This line includes not only Lindberg equipment, but, by joint agreement, the complete line of Upton Salt Bath Furnaces, manufactured by Upton Electric Furnace Company, Roseville, Michigan.

This combination of Lindberg, with its long experience in all types of industrial heating equipment and Upton, leading specialists in salt bath furnaces, will provide industry with more efficient service in the important salt bath furnace field.

Lindberg and Upton engineers and technical staffs are available to assist you in applying salt bath furnace techniques most efficiently to your production processes. Just get in touch with your nearest Lindberg Field Representative (see your local classified phone book) or write us direct. Salt Bath Furnace Division, Lindberg Engineering Company, 2466 West Hubbard Street, Chicago 12, Illinois. Los Angeles plant: 11937 South Regentview Avenue, at Downey, California.

Upton deep submerged electrode Salt Bath Furnace. Available in depths and lengths up to 40 feet or more.

Continuing Graphite Electrodes, an exclusive Upton feature, eliminate bath contamination and provide exceptional savings in electrode costs over conventional, overhanging metal electrodes.

WILSON "ROCKWELL"

HARDNESS TESTERS

WORLD'S STANDARD OF ACCURACY

ACCO for Better Values

EQUIPMENT for EVERY Hardness Testing Requirement

No matter what your hardness testing requirements are, there's a WILSON "ROCKWELL" instrument to do the job. Choose from this complete selection of hardness testers:

"ROCKWELL"—for most hardness testing functions.

Superficial—for extremely shallow indentations.

Twintester—combines functions of "ROCKWELL" and "ROCKWELL" Superficial testers.

Semi-Automatic (manual feed) and Fully Automatic—for automatically classifying tested pieces as CORRECT, TOO HARD, or TOO SOFT—at test rates up to 1000 pieces per hour.

Special Machines—for testing large objects, obtaining internal readings, and other unusual applications.

ALL WILSON "ROCKWELL" hardness testers provide these advantages:

Accurate performance—precision built, with exact calibration, for consistently correct results.

Long life—durable as a machine tool.

Easy operation—even an unskilled operator can get perfect readings. All controls conveniently grouped.

Easy maintenance—interchangeable mechanisms, with spindles mounted on oil-less bearings.

DIAMOND "BRALE" PENETRATORS
for perfect testing every time

A perfect diamond penetrator is essential to accurate hardness testing. Since one point of hardness on the "ROCKWELL" scale represents only 80 millionths of an inch of penetration—only 40 millionths on a Superficial tester—the slightest imperfection will cause a false reading.

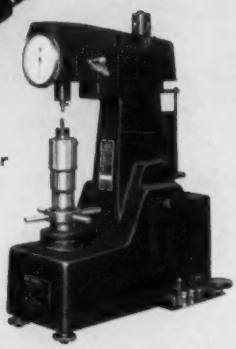
Only *perfect* Wilson Diamond Brale Penetrators are sold. Each diamond is flawless, with no chips or cracks. It's cut to an exact shape. Microscopic inspection and a comparator check of every diamond—one at a time—assure this perfection—and assure you of accurate hardness testing every time.

A COMPLETE LIBRARY of Helpful Information

A wide variety of bulletins tells about hardness testing, and describes the many instruments, accessories, and services Wilson offers. Write for your choice:

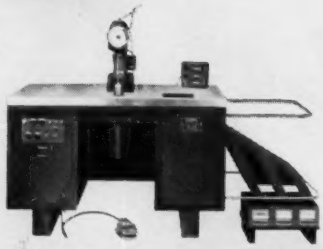
DH-325 — WILSON "ROCKWELL" Hardness Testers • **DH-326** — "ROCKWELL" Superficial Hardness Testers • **DH-327** — Special "ROCKWELL" Testers, including Automatic and Semi-Automatic models • **DH-328** — TUKON Tester, for precision MICRO and MACRO testing

"ROCKWELL"



Twintester

Superficial



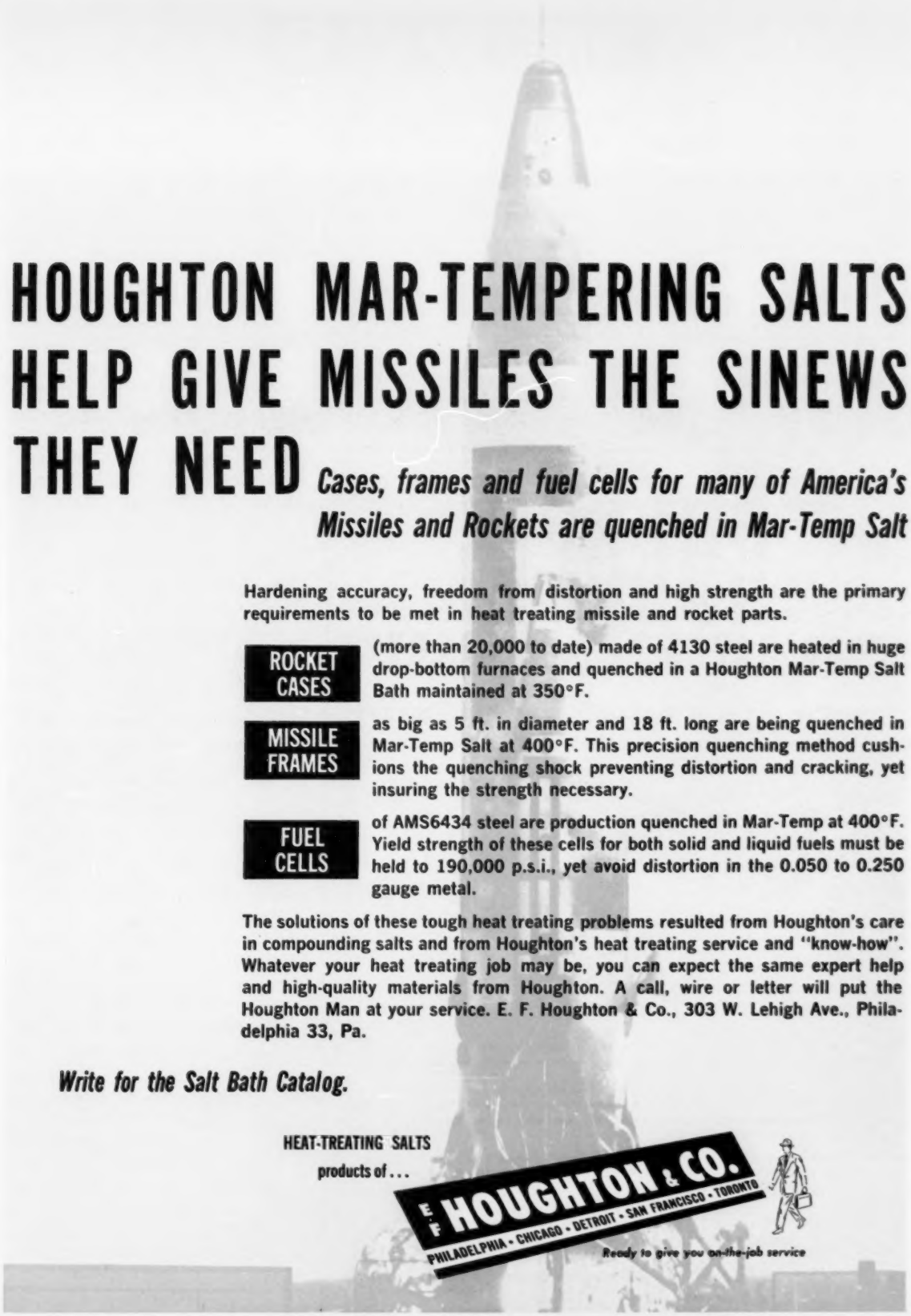
Automatic

TUKON Tester (for MICRO and MACRO testing)

ACCO **WILSON**

MECHANICAL INSTRUMENT DIVISION
AMERICAN CHAIN & CABLE

230-R Park Avenue, New York 17, N. Y.



HOUGHTON MAR-TEMPERING SALTS HELP GIVE MISSILES THE SINEWS THEY NEED

Cases, frames and fuel cells for many of America's Missiles and Rockets are quenched in Mar-Temp Salt

Hardening accuracy, freedom from distortion and high strength are the primary requirements to be met in heat treating missile and rocket parts.

ROCKET CASES (more than 20,000 to date) made of 4130 steel are heated in huge drop-bottom furnaces and quenched in a Houghton Mar-Temp Salt Bath maintained at 350°F.

MISSILE FRAMES as big as 5 ft. in diameter and 18 ft. long are being quenched in Mar-Temp Salt at 400°F. This precision quenching method cushions the quenching shock preventing distortion and cracking, yet insuring the strength necessary.

FUEL CELLS of AMS6434 steel are production quenched in Mar-Temp at 400°F. Yield strength of these cells for both solid and liquid fuels must be held to 190,000 p.s.i., yet avoid distortion in the 0.050 to 0.250 gauge metal.

The solutions of these tough heat treating problems resulted from Houghton's care in compounding salts and from Houghton's heat treating service and "know-how". Whatever your heat treating job may be, you can expect the same expert help and high-quality materials from Houghton. A call, wire or letter will put the Houghton Man at your service. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

Write for the Salt Bath Catalog.

HEAT-TREATING SALTS
products of . . .

E. F. HOUGHTON & CO.
PHILADELPHIA • CHICAGO • DETROIT • SAN FRANCISCO • TORONTO

Ready to give you on-the-job service

ABSTRACTS

DEW POINT MONITORING

by
A. R. Keefe
Plant Engineer
and
M. R. Koehn
Assistant Chief Metallurgist
Axle Division
Eaton Manufacturing Company
Cleveland, Ohio

Round-the-clock monitoring of five endothermic gas generators and six heat treating furnaces is paying off in better quality carburizing at the Axle Division of Eaton Manufacturing Company, Cleveland.

Case depth, carbon level, and hardness are held to close limits with minimum supervision.

The company makes all of the gears for its products. To develop the surface wearing qualities and tough core properties needed in truck service, alloy carburizing steels are used. Controlled carburizing and hardening operations become prime considerations in the manufacture of the axles.

Carburizing is done in six large pusher-type radiant tube, gas-fired furnaces. Four of the furnaces are designed for automatically quenching the parts. The other two units require manual quenching, or are used for carburizing only with subsequent reheating and manual quenching from three controlled atmosphere furnaces. Press quenching is necessary on all ring gears to maintain size and shape.

Built by Surface Combustion Corporation, Toledo, Ohio, the furnaces can process up to 1600 points an hour. Gas atmospheres for carburizing and hardening are supplied by five Surface RX endothermic gas generators which can produce over 15,000 cfh.

All five generators are in daily use, and a sixth unit is kept on standby. The generators are on a balcony above the furnaces; the arrangement saves valuable floor space and permits better housekeeping.

Monitoring System

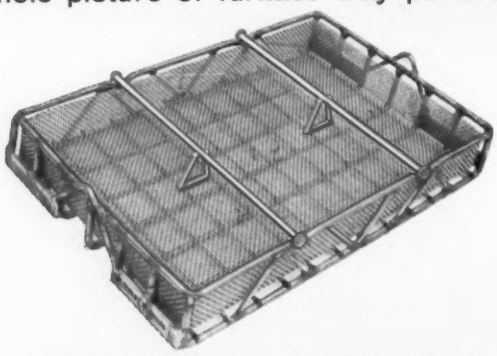
Eaton plant engineers and metallurgists devised the following sequence of using, sampling, and checking the RX generator gas, the carburizing gas, and the heat treated product:

1. The atmosphere from the RX gas generators is piped into a common manifold which leads into a gas accumulator where the gases mix to form a common dew point.
2. Atmosphere samples are taken at each generator, at the gas accumulator where any soot will be removed, and at the furnaces. Each furnace's zone can be sampled individually. Copper sampling lines ¼ in. in diameter extend from each check point to the heating office where

(Continued on page 24)

ROLOCK
HEAT AND CORROSION RESISTANT
FABRICATED ALLOYS

Patented Rolock design has changed
(U.S. Pat. No. 2807454, Sept. 24, 1957)
the whole picture of furnace tray performance



- Travels easily and smoothly over hearth, with bottom bars acting as sleds.
- When used two-high, stacking bars provide adequate support and also prevent side-slide.
- Live-load to basket weight ratio often better than 10 to 1.
- All-Inconel construction with Rolock-quality precision pressure welding.
- Longer furnace hour expectancy than any other known tray design.
- Lowest cost per hour of use.

Why not enjoy this superior performance in Ipsen, Lindberg, Eclipse and other furnaces with this type of hearth? Place your next order for trays with **Rolock.** Trays and liners shipped from stock.

SALES AND SERVICE REPRESENTATIVES FROM COAST TO COAST
ROLOCK INC., 1332 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

1RLSR

now a

ROTATING BURNER

for CINCINNATI flamatic® Flame Heating Machines!

- **flame head spins within the area of the part to be heated**
- **simplifies spin hardening of parts difficult to rotate—eliminates expensive fixtures**
- **cuts hardening costs all around**

This newest development of the Meta-Dynamics Division Heat Treating Laboratories brings lower costs to precision selective flame heating of a wide range of parts, because the flame head rotates—*not* the work. The gas-tight rotating joint of the burner has undergone more than 1000 hours of test, with no sign of leakage.

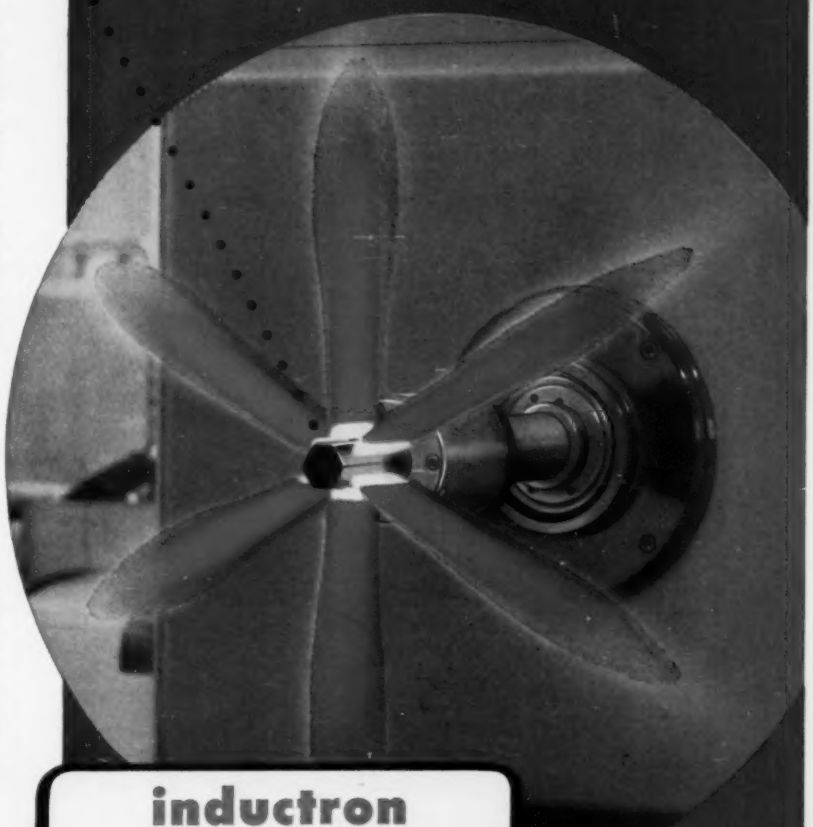
The rotating burner and workholding fixture mount on the flat bed of the basic machine, which contains a quench tank and part removal conveyor. Automatic timing, temperature and quenching control are provided. A separate control cabinet provides accurate control of gas, oxygen, air and water. Other "building blocks" (flame heads and fixtures) are available for such work as brazing and spot, spin, progressive and combination spin-progressive hardening.

For your heat processing work, look to the Cincinnati Flamatic for lowest cost flame heating . . . and the Cincinnati Inductron (built in 15, 30, 50 KW capacities) for lowest cost induction heating. Call in a Meta-Dynamics Division field engineer for full details.

TYPICAL PARTS SUCCESSFULLY HARDENED BY THE FLAMATIC ROTATING BURNER

INTERNAL THREAD of steering knuckle control arm, a pearlitic malleable casting, hardened to Rc 58-60. I.D. is 1 13/16"; thread length, 1 1/4"; overall part length, 22 1/2".

INTERNAL TEETH of SAE 1052 Ring Gear, hardened to Rc 58-60. Gear I.D. is 5 1/4"; tooth face, 3/8".



inductron flamatic *hardening machines*

META-DYNAMICS DIVISION
Machines for Metal Forming and Heat Treating

THE CINCINNATI MILLING MACHINE CO.
Cincinnati 9, Ohio, U.S.A.

CINCINNATI

(Continued from page 22)

the recorded dew points are under constant scrutiny.

3. Two multipoint Surface Autocarb dew point recorders are in the heat treat office next to a switchboard-type distribution panel. The panel is the receiving point for the sampling lines and also serves as the distribution point to the dew point recorders.

Gases Are Mixed

Normally, the five generators are on test 24 hours a day. Should one of them wander out of range, it will be spotted immediately and adjusted. All gas-air ratios are controlled manually at the generators.

In using a system of mixing the product of the five generators, the total mixture will vary only slightly should any of the units be off-range. With constant monitoring of the gas, there is no serious change in the atmosphere at the furnaces, keeping the dew point factor in carburizing almost constant.

To furnish necessary carbon potential for carburizing, natural gas is introduced with the generator gas in the carburizing zone of the furnace. The other zones receive only straight generator gas, which has a dew point of about plus 20° F. Furnace atmosphere is checked only once each workshift after the furnace is regulated.

The front of the distribution panel has quick-snap connectors which connect the sample lines to the recorders. Checking the dew point from any of the sampling lines is simple.

Metallurgical Checks

The metallurgical department makes several checks each day. This department also keeps quality control charts showing carbon level, case depth, microstructure, and hardness. Standard ½-in. diameter test samples are run through the furnaces with the regular work every 2 hours. These are direct quenched in oil.

One from each furnace per day is checked by the metallurgical laboratory. The tests indicate when adjustments of the carburizing atmospheres are necessary. The other test pieces are fractured and etched by the furnace operators.

Once each week a production workpiece from one of the furnaces is given a complete metallurgical examination. Accompanying the workpiece is a carbon gradient test bar and shim stock specimen used to evaluate the carbon potential of the atmosphere. At this time, the furnace atmosphere is checked for gas composition and dew point.

Depth Ranges

Two standard case depth ranges are specified for the gears used in the axles. One range is 0.040" to 0.055"; the other is 0.050" to 0.065". The depth is always held to the high side of the ranges.

Source—STEEL, October 13, 1958

Heat-Treating BASKETS BOXES and TRAYS

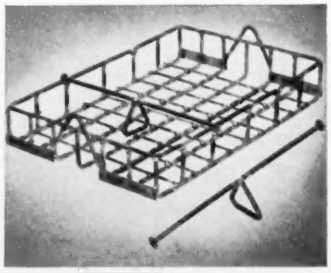
Fabricated to deliver TOP PERFORMANCE

Soundly constructed of heat and corrosion-resistant wrought alloys our lightweight baskets, boxes and trays, yield maximum efficiency per dollar of investment.

Available in compact sizes and designs that will handle a wide range of work, they more than meet all accepted standards for efficient, economical, heat-treating operations involving the continuous production of properly treated products.

We offer practical experience based on our many years of fabricating heat-treat containers of all types, including the attendant problems of design and alloy selection, to withstand the endless variations of load, temperature, atmosphere and support.

Our sales engineers will be pleased to furnish you with complete details regarding the design or redesign of furnace containers that meet your requirement.



A DESIGN FOR ALL TEMPERATURE REQUIREMENTS

Gas Carburizing, Annealing, Carbo-Nitriding, Brazing, Normalizing, Malleableizing, Dry Cyaniding and other heat-treatments

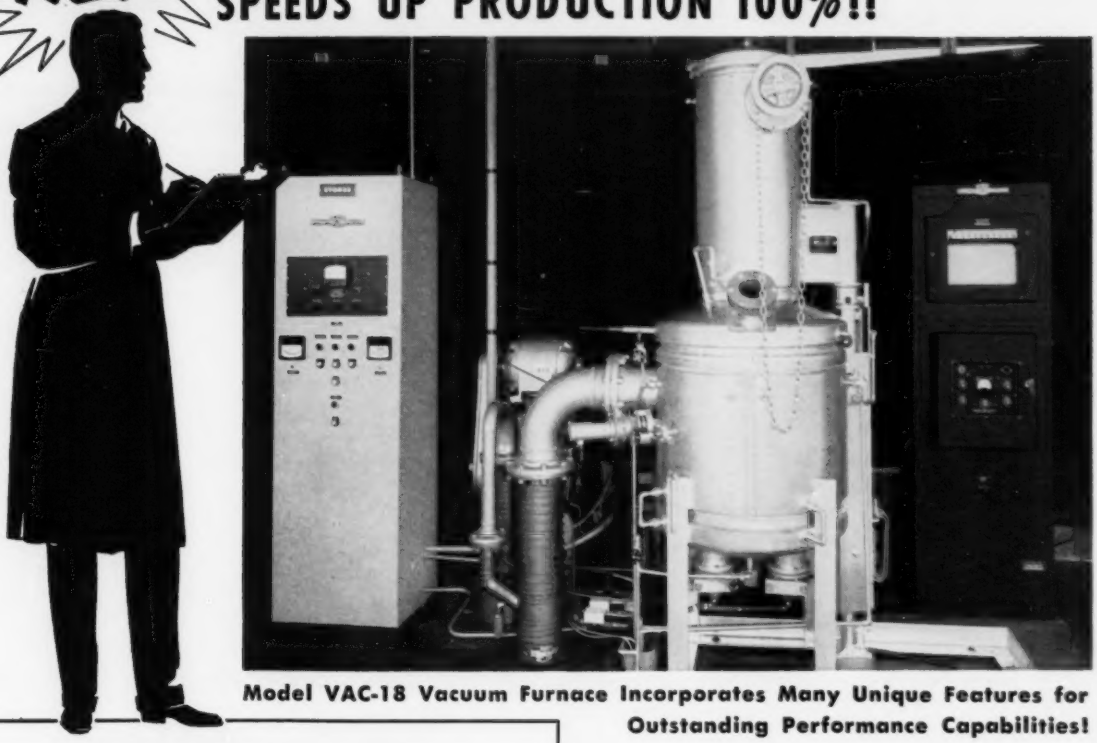
ALLOY STEEL Fabrication Division

ALUMINUM and ARCHITECTURAL METALS COMPANY

1974 Franklin Street • Detroit 7, Michigan • Phone: LOrain 7-6880

DESIGNERS AND PRODUCERS OF ALLOY STEEL AND NON-FERROUS METAL FABRICATIONS

NEW HAYES *Vacuum* HEAT TREATING FURNACE SPEEDS UP PRODUCTION 100%!!



Model VAC-18 Vacuum Furnace Incorporates Many Unique Features for Outstanding Performance Capabilities!

MODEL VAC-18 FEATURES . . .

- ★ Temperature Range . . . from 700°F to 2050°F.
- ★ Vacuum . . . set to operate at 0.1 micron, but will operate at different vacuums . . . as required.
- ★ Heating element of completely new design . . . operates at low voltage; allows heavier, self-supporting construction; eliminates need for refractory inside furnace.
- ★ Heating element operates on 3 phase current; arranged to come to uniform temperature; of simple construction, relatively inexpensive, and easily replaced; water-cooled leads and terminals.
- ★ "Hard-to-clean" baffles eliminated from inside unit . . . entire inner chamber of nickel-clad steel to speed up heating cycle.
- ★ Hydraulic lift raises unit head (and integral cooling chamber) to facilitate work handling.
- ★ Water-cooled, fully jacketed chamber throughout . . . except for weld areas subjected to vacuum.
- ★ Saturable Reactor type power control maintains temperature of element . . . eliminates "on-off" control.

Metallurgical vacuum processing advances another great step toward meeting the severe performance demands of modern industry . . . with the introduction of the new Hayes Model VAC-18 Vacuum Heat Treating Furnace. Many unique features are incorporated in its design . . . to speed up the heating and cooling cycles . . . to facilitate work handling . . . and to improve process control and work-heating qualities.

Request complete information on these and other design features that make the Hayes Model VAC-18 Vacuum Furnace so completely new and outstanding in performance characteristics. Improve your product, increase output, and reduce unit costs . . . with GUARANTEED RESULTS! Let us show you what over fifty years experience in developing the well known line of CERTAIN CURTAIN electric furnaces and allied equipment can do for you. Write today!!

NOW OVER 5000 SF

ELECTRIC CERTAIN CURTAIN FURNACES

C. I. HAYES, INC.

Established 1905

816 WELLINGTON AVE. • CRANSTON 10, R. I.

Free Literature

Please send complete data on the heat treating procedure checked here —

- ☐ Vacuum Heat Treating
- ☐ High Speed Hardening
- ☐ Tool Steel Hardening
- ☐ Carbo-Nitriding
- ☐ Tempering
- ☐ Bright Heat Treating
- ☐ Stainless Steel Heat Treating
- ☐ Sintering
- ☐ Copper Brazing and Soldering
- ☐ Lead Pot Hardening and Tempering
- ☐ Atmosphere Equipment
- ☐ Other . . . . . .

M.T.I. *Activities*

MTI ANNUAL ACHIEVEMENT AWARD

At a recent meeting of the Board of Trustees of the MTI, it was decided to augment the prize that is presented to the recipient of the Annual Achievement Award. A cash award of $100 will be presented in addition to the beautifully engraved plaque that has always been presented in the past.

This MTI Annual Achievement Award is made at the discretion of a Committee appointed to select the best article appearing in *Metal Treating* magazine or the most outstanding lecture presented at any meeting of the Institute.

This year's Award will be presented at the 1959 Annual Meeting of the Institute and all articles appearing in any issue of *Metal Treating* from September-October 1958 through July-August 1959 or any lectures given at the 1958 Annual and 1959 Spring meetings are eligible for consideration.

1959 MTI SPRING MEETING

Definite arrangements and dates have now been made for the forthcoming Annual Spring Meeting of the MTI. This year it will be held at the Hollywood Beach Hotel and Country Club, Hollywood-By-The-Sea, Florida, on Wednesday, Thursday, and Friday, April 22, 23, and 24.

The facilities of this famous resort for the technical and business sessions as well as for pleasure are excellent. A balanced technical program is being arranged for the morning sessions, and each afternoon and evening will be devoted to the use of the outstanding recreational facilities. The technical sessions will feature a panel discussion on the following topics: "Customer Goods Insurance," with discussion being led by Charles H. Hewitt of Dayton Forging & Heat Treating Company; and "New Developments in Quenching," with William E. Engelhard of Owego Heat Treat, Inc., leading the discussion.

Also during one session Mr. E. N. Case, Sales Manager of Ajax Electric Company of Philadelphia will present an illustrated talk on the subject "The Prediction of Carburizing Cycles."

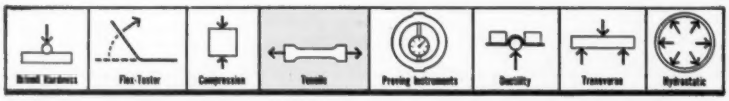
Among the recreational activities being planned besides swimming and golfing is a deep-sea fishing tournament.

TEXAS CHAPTER MEETS

A meeting of the members of the Texas Chapter of the MTI was held on Wednesday, February 18th, in the Houston Engineering Society Building, Houston, Texas. The formal meeting followed luncheon, and the following were present:

Clifford M. Cook
Cook Heat Treating Co. of Texas
LaMar J. Vieau, Jr. and Edward F. Moore, Jr.
Houston Heat Treating Company, Inc.
Charles F. Dominy
Superior Heat Treating Company
L. J. Van Dorfy and Kenneth W. Ward
Lone Star Heat Treating Corporation

(Continued on page 41)



PORTABLE TENSILE TESTER
—You can take it with you!

With a Steel City Portable Tensile Tester, you can pull a tensile test wherever you want—in the field or in the shop. For shop or test trailer, everything but the pump can be wall-mounted to save space. It can be carried by two men and is rugged enough for moving in the shop or in the field.

Flat or round specimens, cast coupons or weld samples can be pulled apart with forces up to 40,000 lb. Tester is easily adjusted for specimens from 5 to 13 inches long. Wedge-type jaws for flat specimens; special V-type jaws for round ones. Hydraulic pressure built up with manual pump. Cylinder stroke is 1¾ in. Gage, 8½ in. OD, has maximum indicating hand.

Write or call Steel City if you have any testing problems.

•

Distributors in most major metalworking areas.

Steel City Testing Machines Inc

8805 Lyndon Avenue, Detroit 38

Tool Steel Topics

BETHLEHEM STEEL

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

TO ALL TOOL AND DIE MAKERS:
BETHLEHEM ANNOUNCES AIR-4, A NEW FREE-MACHINING TOOL STEEL WHICH AIR-HARDENS AT LOW TEMPERATURE STOP AIR-4 HAS EXCELLENT FREE-MACHINING CHARACTERISTICS BECAUSE OF ADDITION OF LEAD STOP OTHER OUTSTANDING PROPERTIES INCLUDE EXCELLENT WEAR RESISTANCE AND HIGH TOUGHNESS FOR GENERAL-PURPOSE TOOLING STOP AIR-4 IS A DEEP-HARDENING GRADE AND HARDENS AT ABOUT 1550F STOP OTHER ADVANTAGES INCLUDE 1. SAFE HARDENING 2. MINIMUM SIZE CHANGE DURING HEAT-TREATMENT
3. LOW HEAT-TREATMENT COSTS AND MINIMUM DECARBURIZATION STOP
WRITE BETHLEHEM STEEL COMPANY, BETHLEHEM, PA., FOR FULL DETAILS

MAKE THE FACILITIES OF A COMMERCIAL HEAT TREATER YOUR METAL TREATING DEPARTMENT

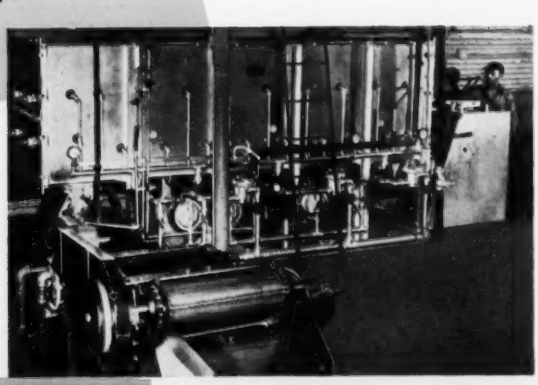


FIGURE ONE

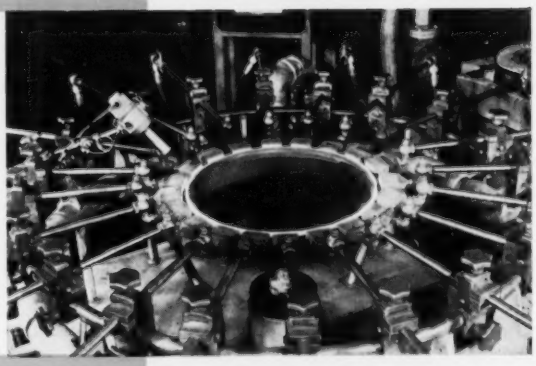


FIGURE TWO

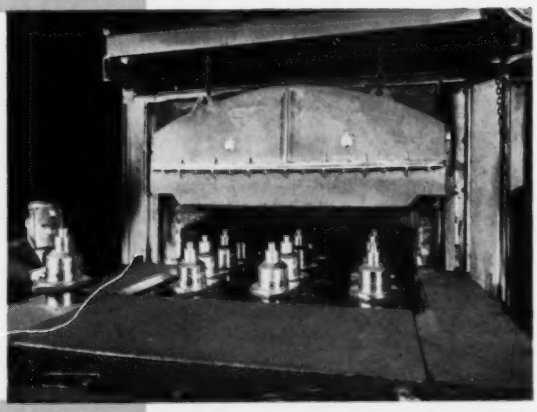


FIGURE THREE

An MTI commercial heat treater is located near you and is ready to serve your needs by performing "Custom-tailored" heat treating operations.

Because all members of the MTI are specialists with complete service facilities centralized in one plant, they are equipped to offer you a variety of heat treating processes—atmosphere hardening, carburizing, nitriding, annealing, cyaniding, etc.

For example, Fig. 1 shows an installation of a shaker hearth furnace with a continuous automatic quenching tank and a conveyor to a washing machine.

Fig. 2 illustrates a gas flame hardening unit featuring accurate temperature control and using two semi-circular gas manifolds mounted on movable carriages with 20 or more burner heads.

A further example of versatile and dependable equipment found in a commercial heat treating plant is seen in Fig. 3. The specially designed furnace conveyor belt carries over 35 lbs. per sq. ft. in normal service and sometimes as much as 5000 lbs. are loaded on it with pieces ranging from ½ lb. to 100 lbs. and temperatures up to 1650°.

Possessing such equipment together with many other specialized facilities and employing the trained personnel with technical knowledge and experience is the business of the commercial heat treater. Teamwork between him and the manufacturer can cut *your* costs.

Get in touch with the Metal Treating Institute or any MTI member listed on the facing page when you need heat treating services.

METAL TREATIN

271 NORTH AVENUE • NEV

of these HEAT TREATING SPECIALISTS

ALABAMA

Southern Metal Treating Co., Inc.
3131 10th Ave. N., Birmingham 4

CALIFORNIA

Certified Steel Treating Co.
2454 E. 58th St., Los Angeles 58
Hollywood Heat Treating Co.
1041 N. Mansfield Ave., Los Angeles 38
Lindberg Steel Treating Co.
2910 S. Sunol Drive, Los Angeles 23
Cook Induction Heating Co.
4925 East Slauson Ave., Maywood

CONNECTICUT

Commercial Metal Treating, Inc.
89 Island Brook Ave., Bridgeport 6
Stanley P. Rockwell Co.
296 Homestead Ave., Hartford 12
Ireland Heat Treating Co.
512 Boston Post Road, Orange

ILLINOIS

Senecca Heat Treating Co.
124 S. Batavia Ave., Batavia
Accurate Steel Treating Co.
2226 W. Hubbard St., Chicago 12
Allied Metal Treating Corp. of Illinois
333 N. California Ave., Chicago 12
Dura-Hard Steel Treating Co.
2112 W. Rice Street, Chicago 22
Perfection Tool & Metal Heat Treating Co.
1756 West Hubbard St., Chicago 22
Fred A. Snow Co.
1942 West Kinzie St., Chicago 22
American Steel Treating Co.
P. O. Box 396, Crystal Lake
Eklund Metal Treating, Inc.
721 Beacon St., Rockford
Lindberg Steel Treating Co.
1975 N. Ruby St., Melrose Park
Ipsenlab of Rockford, Inc.
2125 Kishwaukee Street, Rockford
O. T. Muehlemeyer Heat Treating Co.
1500 Preston St., Rockford
Scott & Son, Inc.
1510 First Ave., Rock Island

INDIANA

Quality Steel Treating Company
1630 Locust Street, Anderson

MASSACHUSETTS

Kinetics Corporation
2 Churchill Road, Hingham
New England Metallurgical Corp.
475 Dorchester Ave., South Boston 27
Porter Forge & Furnace, Inc.
74 Foley St., Somerville 43
Springfield Heat Treating Corp.
99 Margaret Street, Springfield
Greenman Steel Treating Co.
284 Grove St., Worcester 5

MICHIGAN

Anderson Steel Treating Co.
1033 Mt. Elliot Ave., Detroit 7
Bosworth Steel Treating Co.
18174 West Chicago Blvd., Detroit 28
Commercial Steel Treating Corp.
6100 Tireman Ave., Detroit 4
Commonwealth Industries, Inc.
5922 Commonwealth Ave., Detroit 8
Standard Steel Treating Co.
3467 Lovett Avenue, Detroit 10
Vincent Steel Process Co.
2424 Bellevue Ave., Detroit 7
State Heat Treat, Inc.
520 32nd Street, S. E., Grand Rapids 8
Lincoln Heat Treat, Inc.
21235 John R, Hazel Park
Royal Oak Heat Treat, Inc.
21419 Dequindre, Hazel Park
American Metal Processing Co.
12000 East Nine Mile Road, Warren

MINNESOTA

Metallurgical, Inc.
900 East Hennepin, Minneapolis 14

MISSOURI

Metallurgical, Inc.
1727 Manchester Ave., Kansas City 8
Lindberg Steel Treating Co.
650 East Taylor Ave., St. Louis 15
Paulo Products Co.
5711 West Park Ave., St. Louis 10

NEW JERSEY

Ace Metal Treating Corp.
611 Grove St., Elizabeth 2
American Metal Treatment Co.
Spring and Lafayette Sts., Elizabeth
Benedict-Miller, Inc.
Marin Ave. & Orient Way, Lyndhurst
Bennett Heat Treating Co., Inc.
246 Raymond Boulevard, Newark 5
L-R Heat Treating Co.
107 Vesey St., Newark 5
Temperature Processing Co., Inc.
228 River Road, North Arlington

NEW YORK

Owego Heat Treat, Inc.
Rural Route 1, Apalachin
Fred Heinzelman & Sons, Inc.
138 Spring St., New York 12
Alfred Heller Heat Treating Co., Inc.
391 Pearl St., New York 38
Lindberg Steel Treating Co.
620 Buffalo Road, Rochester 11
Rochester Steel Treating Works
962 Main Street, E. Rochester 5
General Heat Treating Corporation
206 Sand Street, Syracuse 3
Syracuse Heat Treating Corp.
1223 Burnet Ave., Syracuse 3

OHIO

Queen City Steel Treating Co.
2980 Spring Grove Ave., Cincinnati 11
Ferrotherm Co.
1861 E. 65th St., Cleveland 3
Lakeside Steel Improvement Co.
5418 Lakeside Ave., Cleveland 14
George H. Porter Steel Treating Co.
1273 East 55th Street, Cleveland 3
Reliable Metallurgical Service, Inc.
3827 Lakeside Ave., Cleveland 14
Winton Heat Treating Co.
20003 Lake Road, Cleveland 16
Dayton Forging & Heat Treating Co.
2323 East First St., Dayton 3
Ohio Heat Treating Co.
1100 East Third St., Dayton 2

PENNSYLVANIA

Drever Company
Red Lion Rd. & Philmont Ave.,
Bethayres
Robert Wooler
Dresher
J. W. Rex Co.
834 West 3rd St., Lansdale
Lorenz & Son
1351 N. Front St., Philadelphia 22
Metlab Company
1000 E. Mermaid Lane, Philadelphia 18
Wiedemann Machine Co.
Gulph Road, King of Prussia
Pittsburgh Commercial Heat Treating Co.
49th St., and A.V.R.R., Pittsburgh 1
Pittsburgh Metal Processing Co., Inc.
1850 Chapman Street, Pittsburgh 15

TEXAS

Dominy Heat Treating Corp.
P. O. Box 5054, Dallas
Superior Heat Treating Co., Inc.
P. O. Box 69, Fort Worth 1
United Heat Treating Company
2005 Montgomery Street, Fort Worth 7
Cook Heat Treating Co., of Texas
6233 Navigation Boulevard, Houston 11
Houston Heat Treating Company, Inc.
2100 Quitman Street, Houston 26
Lone Star Heat Treating Corp.
5212 Clinton Dr., Houston 20

WISCONSIN

Allied Metal Treating Corp.
P.O. Box 612, Milwaukee 1
Metal Treating, Inc.
720 South 16th St., Milwaukee 4
Supreme Metal Treating Co.
4440 West Mitchell St., Milwaukee 14
Thurner Heat Treating Co.
809 West National Ave., Milwaukee 4
Wisconsin Steel Treating & Blasting Co.
1114 South 41st Street, Milwaukee 15
Harris Metals Treating Co.
4100 Douglas Ave., Racine

CANADA

Ipsenlab of Canada Limited
27 Bermondsey Road, Toronto 16, Ont.

NSTITUTE

E, N. Y.

MTI
MASTER CRAFTSMEN
METAL TREATING INSTITUTE

Write for the MTI booklet called:

"PROCEDURES FOR PREPARING PARTS FOR HEAT TREATING"

(Continued from page 18)

time being, high-speed steel will be excluded from consideration for reasons that will be evident later.

Areas softened by severe grinding will etch darker than the portions of the surface not affected. Thus it is possible to bring out the effects of grinding heat when all traces of visible burn color have been removed. The simplest way of doing this is to etch for perhaps 30 seconds in 5 or 10 per cent nital. The contrast between tempered spots and the rest of the steel is only moderate but is generally satisfactory.

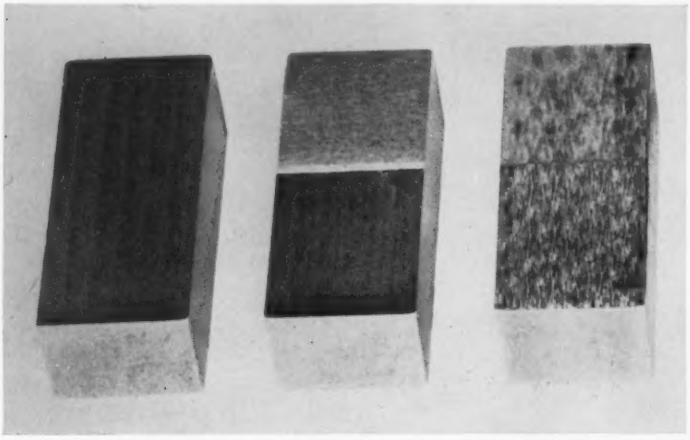


Fig. 2—Samples of hardened tool steel that were burned moderately when ground lengthwise. Part of the burned surface was removed from the piece in the middle by gentle grinding, leaving the upper half apparently unburned. The piece at the right has been similarly cleaned off, but then it was etched in nital and the softened areas became darker than the rest of the surface. (Actual size)

Hardened steel that has not been tempered remains light in color when etched in nital*; tempered steel, on the other hand, darkens when etched, the degree of darkening increasing with the tempering temperature. Hardened steel that is to be ground is likely to be in a tempered condition, and it will etch a light or medium gray.

An example is shown in Fig. 2. All three pieces of a hardened and tempered steel were ground simultaneously end to end, severely enough to leave brown burn marks on the surface, which are visible in the piece on the left. The other two pieces were then ground crosswise very gently with a soft wheel, about half of the burned surface being left untouched. About 0.002" was removed in this manner, the new surface showing no sign of the original burn. The piece on the right was then etched in 10 per cent nital for 30 seconds, and the softened areas etched darker than the rest of the surface. Thus the burn *marks* were made to reappear after the original burn *color* had been purposely destroyed by the gentle cross-grinding operation.

When the grinding conditions are particularly severe in the case of hardened and tempered steel, certain spots in the surface may reach such a high temperature that they become rehardened because they cool instantaneously to the temperature of the rest of the steel, which is relatively cold. If the visible burn marks are ground off and the piece is then etched in nital, the rehardened spots appear white. The area adjacent to each rehardened area must have reached a fairly highly temperature, not enough to cause rehardening, but enough to cause considerable softening, and for this reason it appears dark on etching. The white spots and surrounding dark areas can be seen in Fig. 3. The specimen preparation was exactly the same as that described in the preceding paragraph except that the initial grinding was even more severe and caused rehardening.

* Nital is a metallographic etchant prepared in the laboratory by adding several per cent of concentrated nitric acid to methyl or ethyl alcohol.

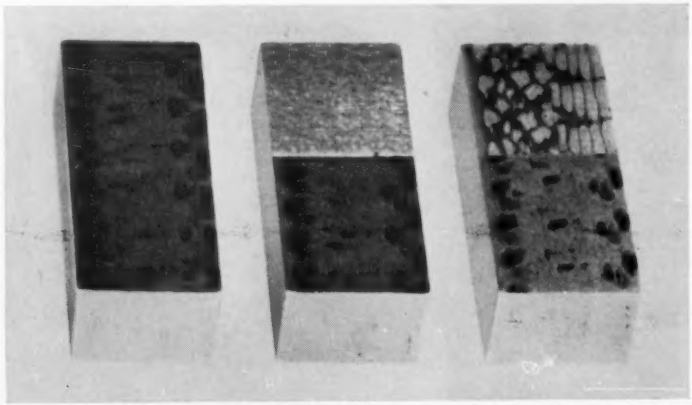
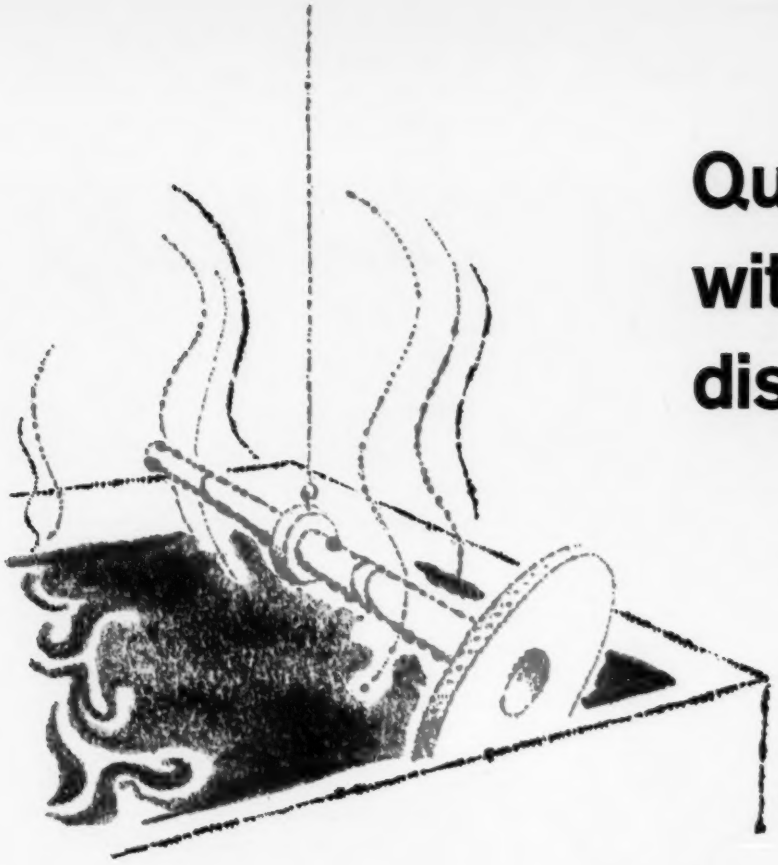


Fig. 3—Samples of hardened tool steel similar to those in Fig. 2 but ground so severely that portions of the surface were rehardened. When the piece on the right was etched in nital, the rehardened areas remained white, while the surrounding soft areas turned dark. (Actual size)

What Is Injury?

Before leaving the subject of detection, it must again be emphasized that observation of some *change* in the condition of a surface following grinding does not mean that the part has been injured. Only when its usefulness in actual service is affected unfavorably can there be talk of *injury*. Thus, ordinarily low carbon steel is not injured by burning it during grinding unless it happens that the surface stresses associated with the high temperatures which resulted in burn are great enough

(Continued on page 36)



Quenching... without distortion

Don't settle for simply the basic advantages of hot oil quenching. Particularly, if you work with special alloy steels, you should get these "extras" that Sinclair Marquenchol can give you... Extra Oxidation Resistance... High Flash and Fire Points... High Viscosity Index... Low Sludge Forming Characteristics

Find out more about MARQUENCHOL. Call your nearest Sinclair Representative or write for free literature to Sinclair Refining Company, Technical Service Division, 600 Fifth Avenue, New York 20, N. Y. There's no obligation.

SINCLAIR

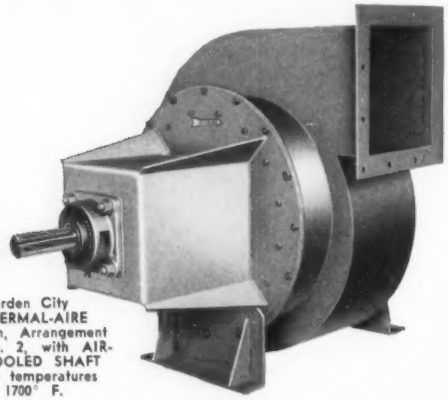
MARQUENCHOL Quenching Oil

A completely NEW line!
GARDEN CITY

RF THERMAL-AIRE FANS

- simple to install
- inexpensive to maintain
- temperatures to 1850°F.

Garden City's new RF THERMAL-AIRE radial blade fans are durable, trouble-free, efficient. Modern, simplified in design, they are "tailored" for various temperatures to precisely meet your needs.



Garden City THERMAL-AIRE Fan, Arrangement No. 2, with AIR-COOLED SHAFT for temperatures to 1700° F.

WRITE TODAY!

Garden City Fan Company
801 North Eighth Street
Niles, Michigan

Send me fully illustrated information on application checked below:

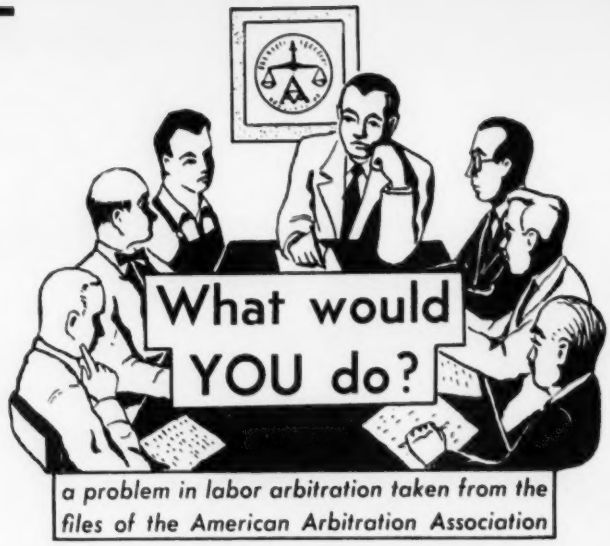
- ☐ **THERMAL-AIRE fans for moving air or gases at elevated temperatures.**
- ☐ **Industrial fans for exhausting dust, fumes and other atmospheric contaminants.**
- ☐ **Industrial fans for material handling of paper, metal and wood shavings, sawdust, etc.**

NAME: .....
TITLE: .....
FIRM: .....
STREET: .....
CITY: ..... **STATE:** .....

GARDEN CITY FAN COMPANY
ESTABLISHED 1879

Representatives in leading cities

801 North Eighth Street, Niles, Michigan (Department T)



a problem in labor arbitration taken from the files of the American Arbitration Association

The Case of the Overtime Hour

One day during the summer of 1958, a designer in a toy factory, working after hours, decided he needed a special mold for a new item he was developing. Since he had once been a machinist, he found it an easy matter to set up one of the metalworking machines and make the mold himself in about an hour.

But when the union steward found out about it the next day, he protested. "The contract says that kind of work must be done by a union member," he reminded the personnel director. "That means you owe the man who would have been next for overtime one hour's pay at time-and-a-half."

Looking at the contract closely, management agreed the designer should not have done that work. "We made a mistake," the personnel manager said, "but the remedy is not giving anyone pay for not working. We are willing to give the top man on the overtime list an extra hour's work. In fact, if you want, we can let him make that same mold over again."

The union didn't agree to that solution. Although there wasn't much money involved, both sides saw it as a matter of principle and sent the case to arbitration under the Rules of the American Arbitration Association.

What Would YOU Do?

THE AWARD: The arbitrator said that to give the aggrieved employee overtime in compensation would just take that amount of work away from someone else in the bargaining unit. The only remedy was an hour's pay. On the other hand, there was no evidence that management would have ordered the mold made on overtime. If the designer had properly observed the contract, the mold would have been made during regular hours. So the arbitrator awarded one hour's pay at straight time to the man the union named.

(Continued on page 49)

NEW PACIFIC FURNACE DESIGN LICKS TITANIUM PRODUCTION PROBLEM!

TITANIUM QUENCH FURNACE— VACUUM PURGE...

...MAINTAINS PURITY

FOR MASS PRODUCTION OF CLEAN, BRIGHT WORK—DURING ENTIRE HEATING CYCLE!

When DESIGN really counts... a specific Pacific Furnace is the answer!

- RAPID VACUUM PURGE
- CONTROLLED ATMOSPHERE DURING HEATING CYCLE
- UNIFORM HEATING AND TEMPERATURE CONTROL
- CASCADE QUENCHING ACTION
- ASSURED END RESULT

For help with YOUR heat treating problem, and for information on a modern Pacific Furnace that's engineered to your specific job —write today!

Overcoming the many problems of heat treating titanium parts in production quantities—and without sacrificing quality—posed special problems for Metallurgical Consultants, Inc.... till Pacific designed a unique new furnace to meet their rigid requirements! As titanium becomes brittle when subjected to many atmospheres, much of its high strength-to-weight ratio is lost, causing the material to become embrittled. Some of the gas is absorbed and penetrates to the core of the work and no mechanical process, such as sand-blasting, can remove the affected material.

To lick this problem, Pacific designed an entirely new vacuum and controlled atmosphere quench furnace that maintains control of the atmosphere not only during the heating cycle, but throughout the entire loading and quenching cycle. Temperatures can be closely controlled and are maintained with unusual stability due to special radiation shields. Several rapid vacuum purges, followed by a back filling with inert gas, protect the work... and prevent the alloying effect which causes titanium to become brittle.

After heating, the work is withdrawn to the purge chamber where the work basket—still under a protective atmosphere—is rotated to let the heated parts be individually quenched in a cascade action. The individual quench plus a controlled atmosphere throughout, provides the results desired—and more important, these results are being obtained on a fast production basis!

Whatever your need—Pacific's creative engineers and metallurgists—will recommend a sound answer. Their experience can bring you special results. Call or write today.

* TRADE MARK

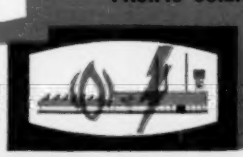
Pacific

CREATIVE DEVELOPMENT AND MANUFACTURING IN FURNACE DESIGN

GAS OR ELECTRIC INDUSTRIAL HEAT TREATING EQUIPMENT

PACIFIC SCIENTIFIC COMPANY

LOS ANGELES
SAN FRANCISCO
SEATTLE
PORTLAND, OREGON
ARLINGTON, TEXAS
SAN DIEGO



PACIFIC SCIENTIFIC COMPANY • P.O. Box 22019, Los Angeles 22, Calif.

☐ Please send me details on custom designed furnaces.

☐ Please send me a copy of your new catalog and full information on Pacific Heat Treating Equipment.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

JANUARY—Bought anhydrous ammonia at bargain price on supplier's vague quality claims . . .

LATER—Moisture in furnace . . . discoloration of finished parts . . . pickling and polishing necessary . . .

STILL LATER—Oil! Pressure regulators clogged . . . dissociator catalyst poisoned . . . incomplete dissociation . . .

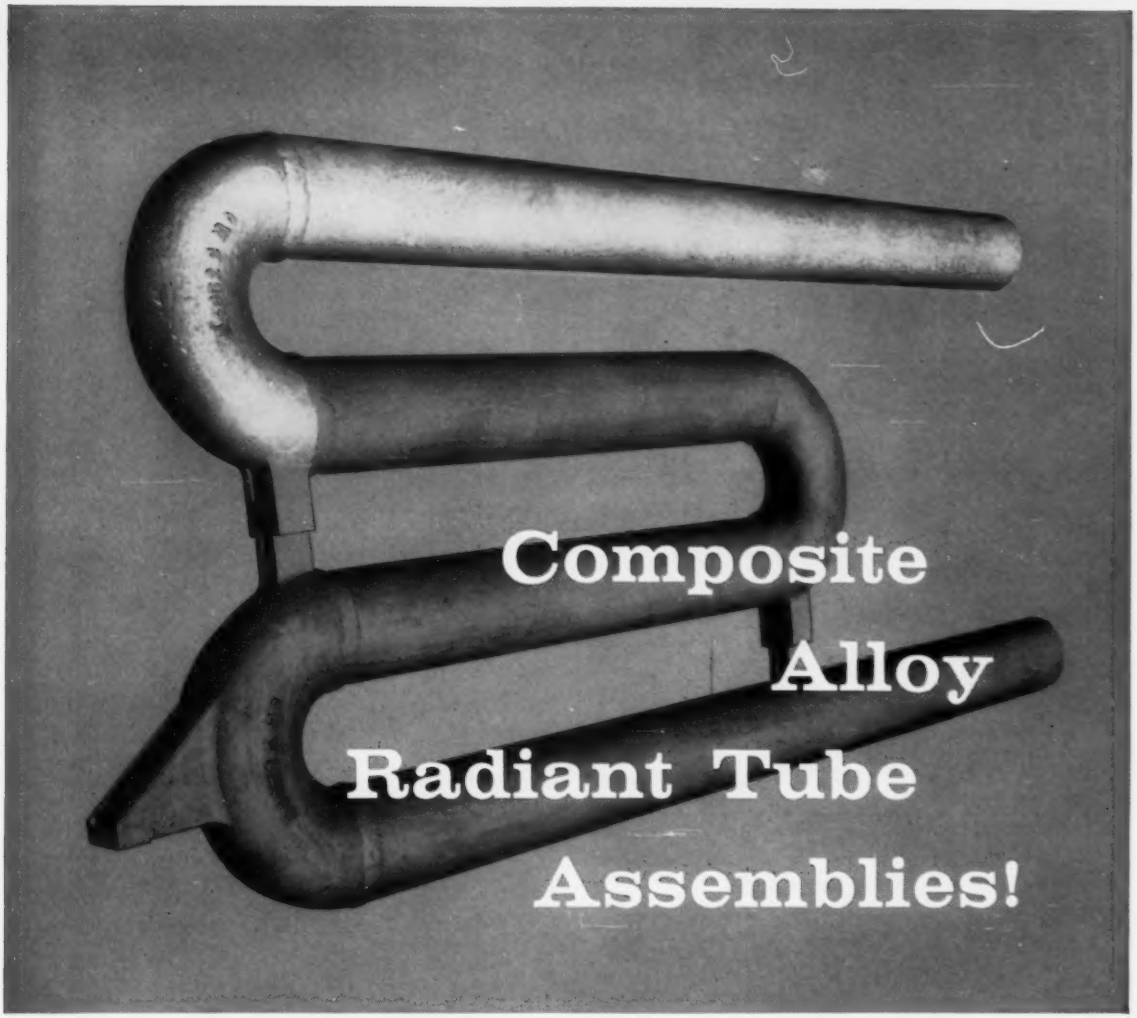
TOO LATE—Parts and profits in scrap pile . . . metal treating line down for replacements and repairs . . .

BE TROUBLE-FREE! Buy the trouble-free ammonia from Armour—purest money can buy!

ARMOUR AMMONIA DIVISION

1355 West 31st Street • Chicago 9, Illinois

Quality ammonia from the most distribution points . . . 171 cylinder stock points, 12 bulk stations!



Critical section of the radiant tube assembly is cast from 22H to provide greater heat resistance.
The balance of the assembly is cast from an alloy of the proper grade for optimum service in individual furnace.

Provide greatly increased tube life

The new National Alloy radiant tube assembly is designed and built for maximum service under the punishing conditions found in all types of radiant tube furnaces. Its special construction puts alloys with greater heat resisting properties into critical sections of the assembly.

In pilot installations this added ruggedness has resulted in two to three times the tube life previously experienced. This fresh approach in meeting the strict requirements imposed by higher heat treating temperatures results from special know-how and infinite care in construction.

As the leading specialist in high temperature alloy castings for radiant tube furnaces, National Alloy has had unique experience in dealing with the problems brought about by elevated temperatures, and the men and machines to give you the practical answer. For the full story on how composite alloy radiant tubes may improve your heat treating operations, contact National Alloy today. No obligation of course.

BLAW-KNOX

BLAW-KNOX COMPANY

National Alloy Division
Pittsburgh 38, Pennsylvania

NA NATIONAL ALLOY

STOP SCALING, CARBURIZATION & DECARBURIZATION DURING HEAT TREATING

MARKAL "C-R" COATINGS protect against oxidation, corrosion, scaling, gas absorption, carburizing and decarburizing during heat-treating, annealing, normalizing or stress-relieving.

MARKAL "C-R" Coatings protect up to 2100° F. steel, stainless steel, copper, copper bronze, nickel bronze, titanium, zirconium, titanium and molybdenum alloys, inconel and monel metals during heat-treating.

MARKAL "C-R" Coatings can be removed easily from surface after operation is completed, in most instances.

Write on company letterhead for complete information. Engineering service available for special problems.

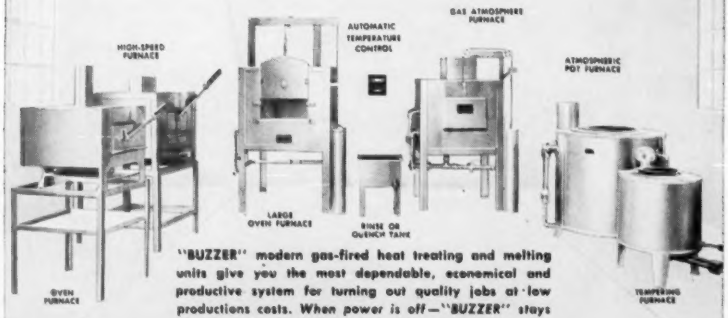
The Mark of Quality . . . MARKAL Protective Coatings

MARKAL COMPANY 3102 West Carroll Avenue, Chicago 12, Illinois

MORE HEAT TREATING VOLUME

with BASIC "BUZZER PACKAGE"

NO BLOWER OR OTHER POWER NEEDED
. . . just connect to gas supply



"BUZZER" modern gas-fired heat treating and melting units give you the most dependable, economical and productive system for turning out quality jobs at low productions costs. When power is off—**"BUZZER"** stays on the job! Standard and special furnaces, large or small, available to equip your shop to exact requirements.

COMPLETE LINE OF BUZZER BURNERS FOR CLEANING, RINSING, PICKLING AND SUNDRY HEAT OPERATIONS

REG. U.S. PAT. OFFICE

WRITE TODAY FOR NEW "BUZZER" CATALOG

CHARLES A. HONES, INC.

145 S. GRAND AVENUE, BALDWIN, L. I., N.Y. • BAldwin 3-1110

HEAT TREATING EQUIPMENT SPECIALISTS SINCE 1911

(Continued from page 30)

to distort the part more than is permissible, either immediately or in service. Even surface cracks are not injurious if the piece lasts just as long and does as good a job as when it is not cracked.

Detection of possible injury is an extremely important part of the problem, yet it is only a part. Injurious changes cannot be avoided unless they can first be detected, but changes in the condition of the surface are not automatically injurious under all circumstances. Whether a given effect, like burn, for example, is to be considered injurious depends upon past experience, and if this is not available, then tests have to be run; otherwise, perfectly satisfactory parts may be scrapped to satisfy a well-meaning but improperly informed inspector. • • •

(Continued from page 17)

ASM SOUTHERN METALS CONFERENCE

The 1959 ASM Southern Metals Conference will be in Augusta, Georgia, on May 4, 5, and 6, hosted by the Savannah River Chapter. Theme of the Conference will be "Metallurgical Frontiers." The Southern Metals Conference, sponsored annually by one of the ASM chapters in the Southeast, is dedicated to promoting a better understanding of the effects of metallurgy and metal working on the scientific and industrial life of the region.

The program of the Conference will feature the many new advances in understanding and use of metals in recent technology, including a discussion of advanced concepts in solid fuel power reactors by Walter H. Zinn, internationally famed nuclear reactor designer, and a review of materials research for outer space ventures by D. W. Gates, missile materials scientist from the Army

(Continued on page 46)

New Protection For YOUR Equipment— At Temperatures Up To 3300°F

ALUNDUM castables offer unusual advantages to all industries using high temperature installations*

Will fire continuously up to 3300°F. This Harrop gas-fired furnace, recently developed by the Electric Furnace Division of the Harrop Ceramic Service Company, Columbus, Ohio, is particularly applicable to the firing of ceramic oxide bodies. Norton ALUNDUM 33-I Insulating Castable selected for the inner lining of the furnace and its roof, provided completely satisfactory protection under repeated tests at highest operating temperatures.

The new Norton ALUNDUM Castables are made in two types: 33-I Insulating and 33-HD Heavy Duty. At temperatures up to 3300°F both types have been extremely successful in protecting high temperature processing — in many industries and many different installations.

ALUNDUM 33-I Insulating Castable is made up primarily of pure aluminum oxide bubbles, tiny and countless. Forming a network of air spaces, it assures excellent insulation, even at highest commercial temperatures.

ALUNDUM 33-HD Heavy Duty Castable is chiefly composed of dense grains of pure aluminum oxide. It is recommended for forming dense monolithic surfaces in many types of furnaces where high temperature conditions are particularly severe.

Both 33-I and 33-HD Castables are very easy to store, mix and use. With them you can cast simple or complex shapes quickly and economically, replace more expensive pre-fired shapes, and cut maintenance and replacement costs to very lowest. Ask your Norton Representative for details, and for the folder *Two Norton Castables.* Or write to NORTON COMPANY, Refractories Division, 622 New Bond Street, Worcester 6, Massachusetts.

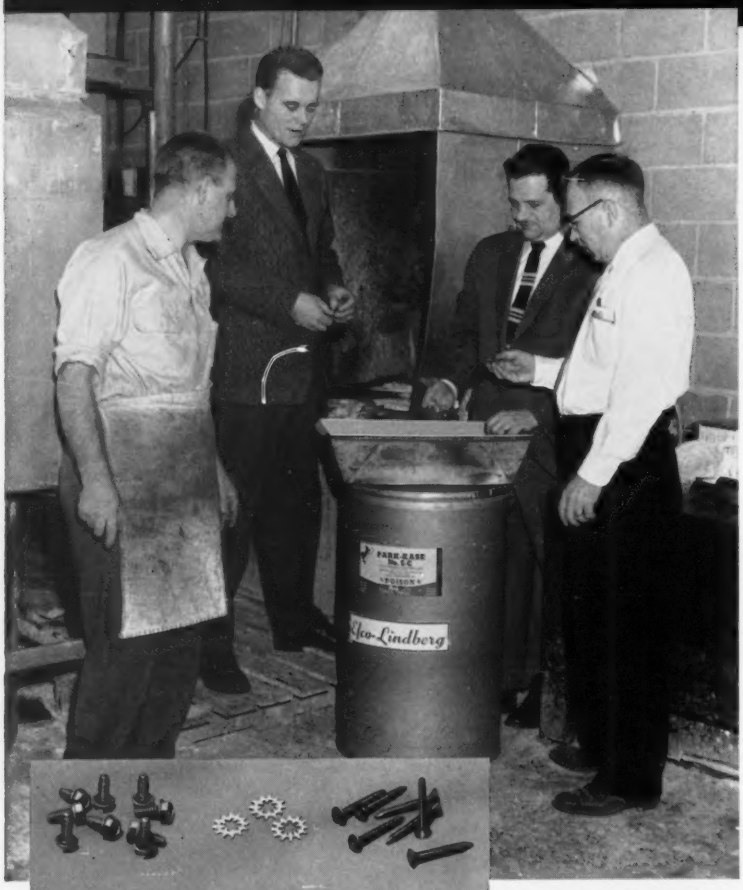
*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

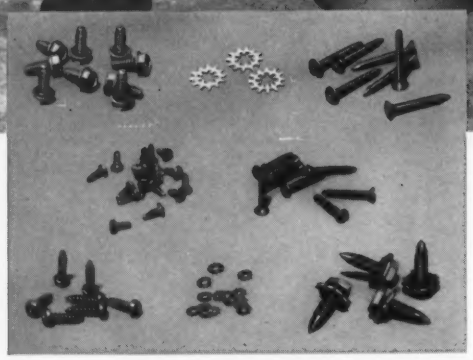
NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

Making better products . . . to make your products better

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — BEAR-MANNING DIVISION Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

"Our Work Has Been Coming Out Much Cleaner Since We Started Using PARK-KASE 5-C"





Reading from left to right: Joseph Catt, Heat Treat Foreman; P. K. Jensen, Efco-Lindberg; Russell Grant, Williams and Wilson, Sales Representative; Jack Harris, Superintendent.

says

Mr. Jack Harris Superintendent of the Shakeproof/Fastex

Division of Canada Illinois Tools Limited, Toronto, Canada

"Clean work means uniform high hardnesses and trouble free operations. We liquid carburize a variety of parts and Park-Kase No. 5-C meets our requirements for case depths and hardnesses. It's not expensive either. Dragout is low and small daily additions maintain the activity of the bath. We use Park-Kase No. 5-C because it produces quality work efficiently and economically."

Park-Kase No. 5-C is a water soluble liquid carburizing salt for light and medium case depths. It carburizes rapidly and uniformly and is easily cleaned from oil quenched or air cooled work. Send for Technical Bulletin A-2 or contact your nearest Park representative for information on how Park-Kase No. 5-C can solve your liquid carburizing problems.

PARK heat treating materials and service are now being provided to Canada's rapidly expanding metal working industry by EFCO-LINDBERG Ltd., 15 Pelham Avenue, Toronto 9, Ontario. Telephone ROger 6-6456.

Park

PARK CHEMICAL COMPANY • 8074 Military Ave. Detroit 4, Michigan

CARBURIZING CYCLES

(Continued from page 7)

Also associated with higher temperatures is usually a tendency for greater distortion. Uniform heating will be essential, and it may be desirable to drop to a lower temperature for quenching. Higher surface carbon will be observed, if maximum penetration rate is to be obtained. Diffusion may be necessary in some cases to compensate for the higher surface carbon. Service life of the equipment is also to be considered since this will affect the economics of high temperature carburizing; it is the present evidence that design problems are capable of practical solution.

Additional work needs to be done and is presently being carried out in the laboratories of the author's company as well as a number of others. Such questions as control of surface carbon, the carbon gradients which are obtained, the amount of grain growth and its control, and physical properties other than hardness are all being studied. As this additional information becomes available, it will help decide the future of high temperature carburizing.

Whatever may happen in the field of high temperature carburizing in the future, we have shown in this discussion that it is possible to calculate case depth by a simple method, and that this method gives results which can be used with confidence in practical heat treating. • • •

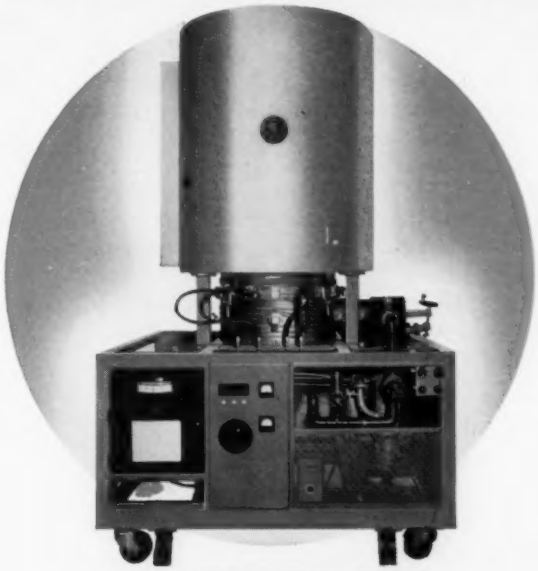
CORRECTION

Inadvertently an error was made in the author byline of an article which was published on page 18 of the January-February issue of *Metal Treating*.

The article entitled "Quality Instruments Permit Better-Than-Standard Test Performance" was written by William F. Carew, Chief Engineer, Joliet Metallurgical Laboratories, Inc., Joliet, Illinois.

Our apologies to Mr. Carew and to the Barber-Colman Co.

HIGH VACUUM
ANNEALING • SINTERING • WELDING • BRAZING & HEAT TREATING



Kinney®

HIGH VACUUM FURNACES

The Bell-type Annealing Furnace shown above is but one of many KINNEY High Vacuum Furnaces developed for improved metal treating. From melting, alloying and casting to degassing, sintering, annealing, brazing and welding, KINNEY provides the High Vacuum equipment to meet your special needs for product improvement.

The approach of KINNEY engineers to modern High Vacuum techniques is based upon many more years of Vacuum "know-how." This is reflected not only in the practicality of the equipment but in the economic advantages in design, operation and maintenance, as well. Write for outline of advanced techniques in vacuum heat treating, or better still, make a date to discuss your Vacuum Furnace problems today!

WRITE FOR LITERATURE DESCRIBING NEW DEVELOPMENTS IN HIGH VACUUM EQUIPMENT

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
3594-D WASHINGTON STREET • BOSTON 30 • MASS.

Please send me your latest literature on KINNEY Heat Treating Equipment ☐ Please have an engineer call me ☐

Name_____

Company_____

Address_____

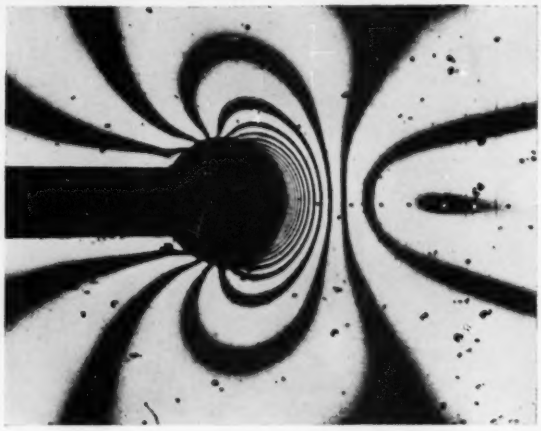
City_____ Zone____ State____

(Continued from page 13)

Need for Heat Treating Experiments

I did notice, however, that many of the disks, both straight- and cross-rolled, had microstructures other than the approved tempered martensite. Fine pearlite was plentiful, and occasional patches in the tempered matrices which might be bainite were seen. Since the tear properties of all these disks were much higher than the properties shown in the earlier tests of the as-rolled pearlitic strip, it seemed that much of the pearlite in the disks might have been formed at high temperatures and was not a residue from incomplete solution. Although there was no relation between the occurrence of the pearlite and the disks' performance, it was significant that the disks were within the prescribed hardness range of Rockwell C 36-44, and in many cases the disks of irregular microstructure had given good service. This could bear investigating and might be a springboard for the heat treating experiments which I felt held out a hope of solution.

Fig. 8—Photoelastic fringe pattern at base of notch in loaded Navy tear test specimen. Original magnification 25x.



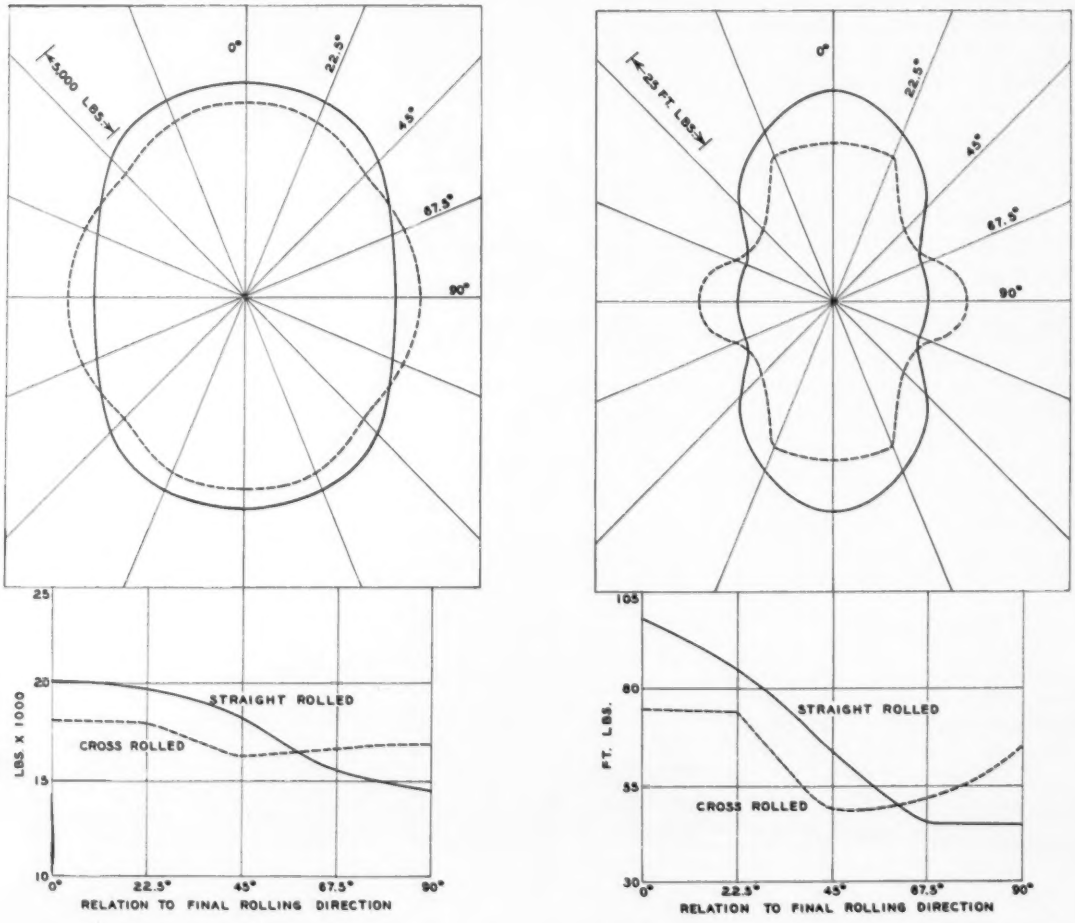


Fig. 7—Strength distribution as shown by Navy tear test, straight- and cross-rolled C-1085 strip steel, hardened-and-tempered.

(Continued on page 42)

M.T.I. ACTIVITIES

(Continued from page 26)

Leon L. Sanders
United Heat Treating Company
C. E. Herington, Executive Secretary
Metal Treating Institute

Various local chapter problems were discussed and some general plans formulated as to the activities of the members in connection with the 1960 Spring Meeting of the MTI, which is going to be held in Dallas, Texas.

BOARD OF TRUSTEES MEETING

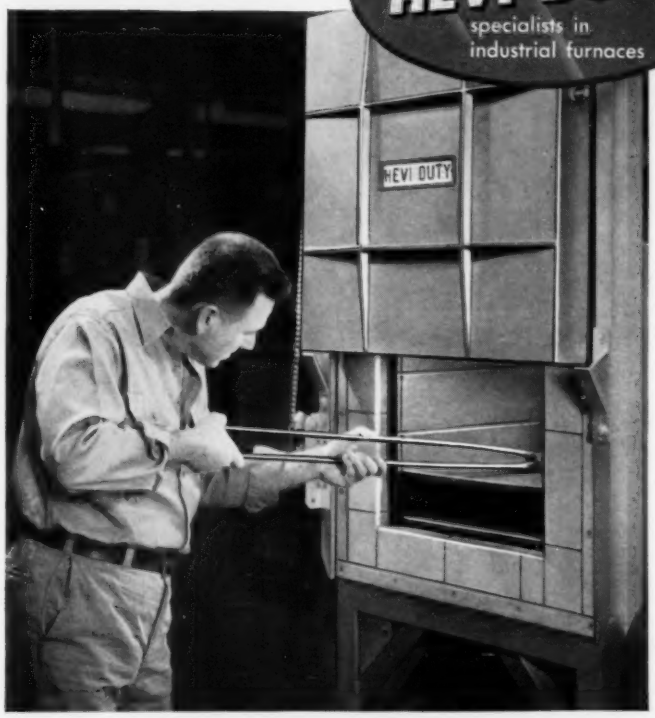
A meeting of the Board of Trustees of the MTI was held in Detroit on Friday, February 20th. The following people were in attendance:

K. U. Jenks
Lindberg Steel Treating Co.
C. R. Weir
Commonwealth Industries, Inc.
L. G. Field
Greenman Steel Treating Co.
E. J. Cox
Pittsburgh Commercial Heat Treating Co.
A. L. De Hart
Fred A. Snow Co.
M. B. Dominy
Dominy Heat Treating Corp.
A. S. Raphael
Standard Steel Treating Co.
J. H. Ries
Lakeside Steel Improvement Co.
H. N. Bosworth
Bosworth Steel Treating Co.
C. E. Herington
Metal Treating Institute

The meeting lasted for a full day, and a very complete agenda of MTI business was covered and many important decisions made and policies established.

USED FURNACE WANTED
Wanted: to purchase used Hevi-Duty Pit Type Electric Furnace, 24" diameter, 60" to 84" deep.
Write or call:
J. L. Crosbie
Fred Heinzelman & Sons, Inc.
138 Spring Street New York 12, N. Y.
WAlker 5-0720

Built by
HEVI-DUTY
specialists in industrial furnaces



Temperite® furnace keeps an eye on steel quality for Universal Cyclops

This Hevi-Duty Temperite furnace plays an important part in quality control at Universal Cyclops Company, Bridgeville, Pennsylvania. It is used in the laboratory for aging high-temperature alloys and for tempering tool steel.

Samples of plate, sheet and bar stock up to 24 inches long are selected at random from the mill production and spot-checked to make sure rigid specifications are met. High-temperature alloys are aged at 1325°F., and tool steels are tempered up to 1100°F.

R. D. Williams, the supervising metallurgist, says that the large capacity and excellent temperature uniformity of the Temperite furnace make possible extremely accurate tests of large batches of samples. He also appreciates the fact that it has required no servicing despite its being used 24 hours a day.

For further details on the Hevi-Duty Temperite furnace, write for Bulletin 355.

- Industrial Furnaces electric and fuel
- Dry Type Transformers
- Constant Current Regulators

HEVI-DUTY ELECTRIC CO.
Milwaukee 1, Wisconsin

(Continued from page 40)

Fig. 9—Two principal stresses at base of notch along center line at right angles to loading.

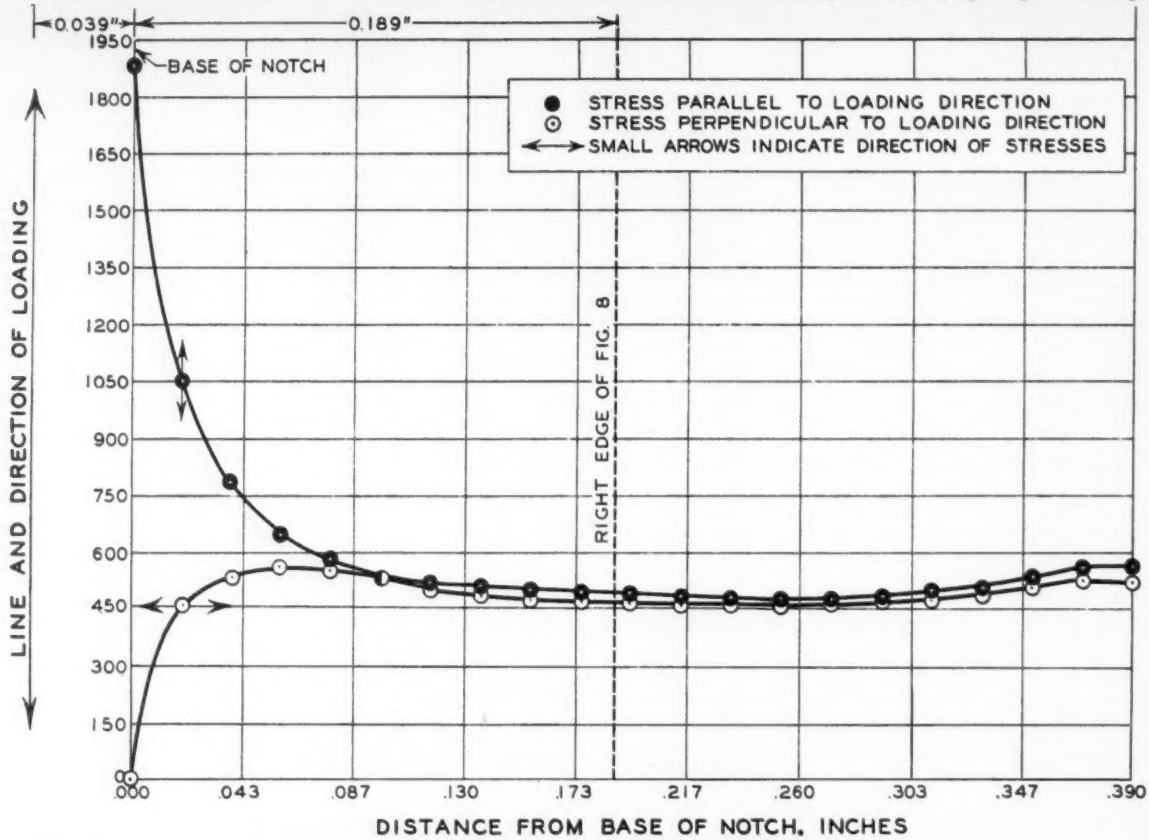


Table IV **SUMMARY OF TEST RESULTS, HEAT-TREATED, STRAIGHT-ROLLED C-1085 STRIP STEEL (AUSTEMPERED: 500°-800°F).**

Property	"Martemper" (hard-temp)	Austemper						
		500°F.	550°F.	600°F.	650°F.	700°F.	750°F.	800°F.
Fracture	Directional	All nondirectional						
Navy Tear Test								
Maximum Load, lbs/in.								
Maximum	122 900	23 200	87 400	139 000	140 700	138 100	133 800	129 900
Minimum	104 500	16 300	43 200	106 200	116 900	116 500	110 000	117 000
Average*	118 400	20 300	73 200	126 300	129 000	129 100	123 100	124 200
Work Absorbed to Fracture, ft-lbs/in.								
Maximum	438	12	173	564	615	565	696	610
Minimum	300	7	102	266	336	383	483	419
Average*	384	11	158	427	501	480	596	531
Extension, in.								
Maximum	0.082	0.016	0.043	0.100	0.105	0.109	0.113	0.108
Minimum	0.070	0.013	0.028	0.061	0.075	0.081	0.093	0.089
Average*	0.073	0.015	0.043	0.082	0.099	0.120	0.103	0.093
Axial Tension Test								
Yield Strength, psi	179 700	Not shown	125 900	200 400	193 300	168 600	143 900	139 600
Tensile Strength, psi	203 800	58 100	141 700	265 200	227 900	207 900	185 300	182 900
Yield/Tensile	0.89	---	0.89	0.75	0.84	0.82	0.78	0.77
Elongation in 2 in., %	8.0	Negligible	Negligible	6.0	8.5	9.0	10.5	11.0

Note: Maximum and Minimum did not always coincide with Parallel and Transverse positions in this group of tests.
***Average of 5 angular positions.**

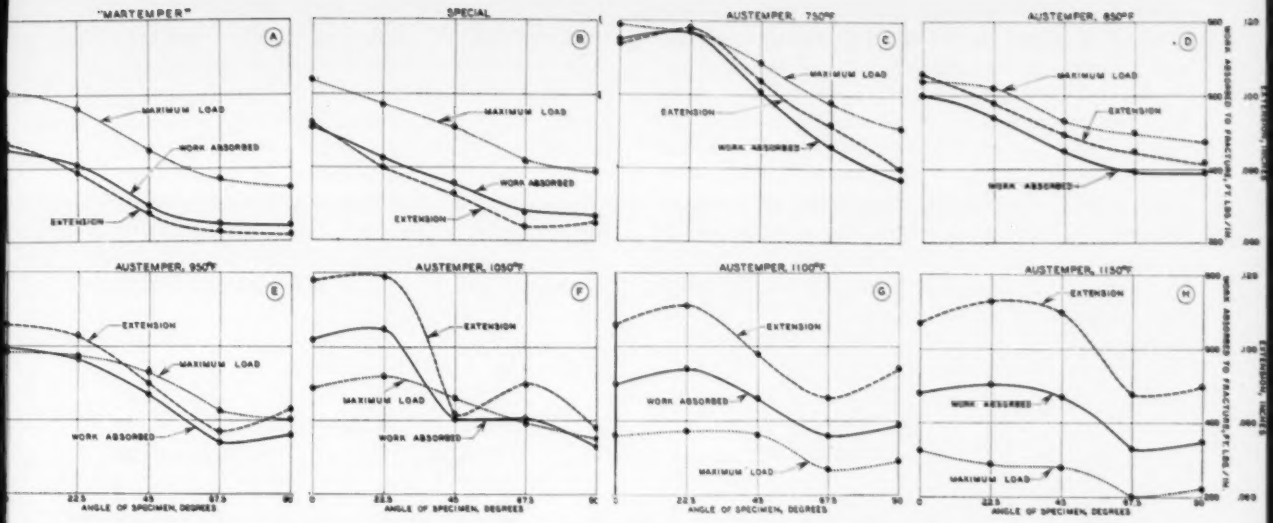


Fig. 10—Navy tear test properties of straight-rolled C-1085 strip steel. A and B, hardened-and-tempered; C-H, austempered 750°-1150° F.

Consequently, in connection with the study of straight-rolled strip steel then in progress, I set up a series of tests on the effect of "hot quenching." Tear test specimens were taken covering the previously used five angular positions, and axial tension and ball test specimens were prepared. The specimens were divided into eight groups. One group was "martempered;" another designated "special," was austenitized at 1575° F and quenched in 350° F oil. Both of these treatments, after tempering, produced a similar-appearing, tempered-martensitic microstructure. The remaining groups were austempered at 750°, 850°, 950°, 1050°, 1100°, and 1150° F for 5 minutes holding time. (See Fig. 13 for representative microstructures and hardness).

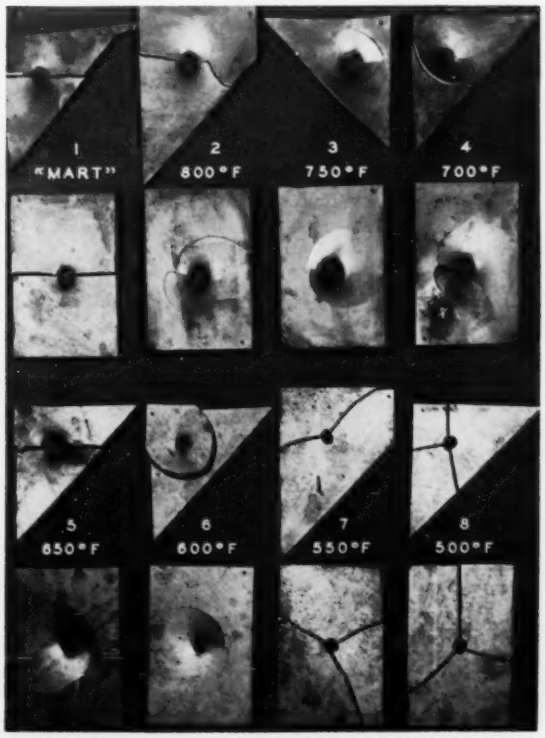


Fig. 11—Ball test fractures, straight-rolled C-1085 strip steel. (1) hardened-and-tempered; (2-8) austempered 800°-500° F.

A glance at the tear-test graphs (Fig. 10) and a summary of the test results (Table III) showed the superior properties of the strip austempered at 750° F. No directional fracture had occurred in tear or ball tests of any of the austempered specimens.

We still had greater strength in the direction of rolling than transverse to it, but this was not too important because the minimum properties of the strip austempered at 750° F exceeded the minimum and approached the maximum properties of the hardened-and-tempered strip. The tendency to directional fracture, which now might be conceded to be strongly influenced by crystalline orientation, had been overcome, and we could forget about the nominally-occurring inclusions. The "better disk" was in sight, and the "impossible project" had entered the realm of the very probable.

Final Tests and Results

The next steps were obvious: to investigate the properties developed by straight-rolled C-1085 strip steel when austempered in the bainitic range, and to austemper some 16" disks in the range that looked best.

Tear, ball, and tension test specimens were prepared and austempered in groups at 50-degree increments, with 10 minutes holding time from 500°-650° F, and 5 minutes holding time from 700°-800° F. Hardened-and-tempered ("martempered") standard specimens were tested along with them.

In the ball test, only the "martempered" specimens showed directional fracture (Fig. 11). Although the results of the tear tests of these specimens austempered at 750° F differed somewhat from those previously ob-

tained, and even though the strength distribution patterns were not as sharply defined and the maximum and minimum did not always occur in the parallel and transverse positions respectively, it was plain from the tear and tension test results (Table IV and Fig. 12) that the bainite with some very fine pearlite, produced by austempering at 750° F had properties far superior to the tempered martensite then approved for disks. Variation in the percentage distribution of the microstructural constituents could account for the irregularities in strength distribution. (See Fig. 13 for representative microstructures and hardness).

of the austempered disks were made, but I was later informed that the austempered straight-rolled disks not only outperformed straight-rolled production disks but were also markedly superior to cross-rolled production disks.

The idea, conceived in the shadowy side indications of laboratory tests and nurtured on their results, had, after almost five years of labor, reached a healthy birth. It was now up to the many people involved in the designing of the new equipment, the perfecting of the production process, and the building of the new factory to bring it to maturity.

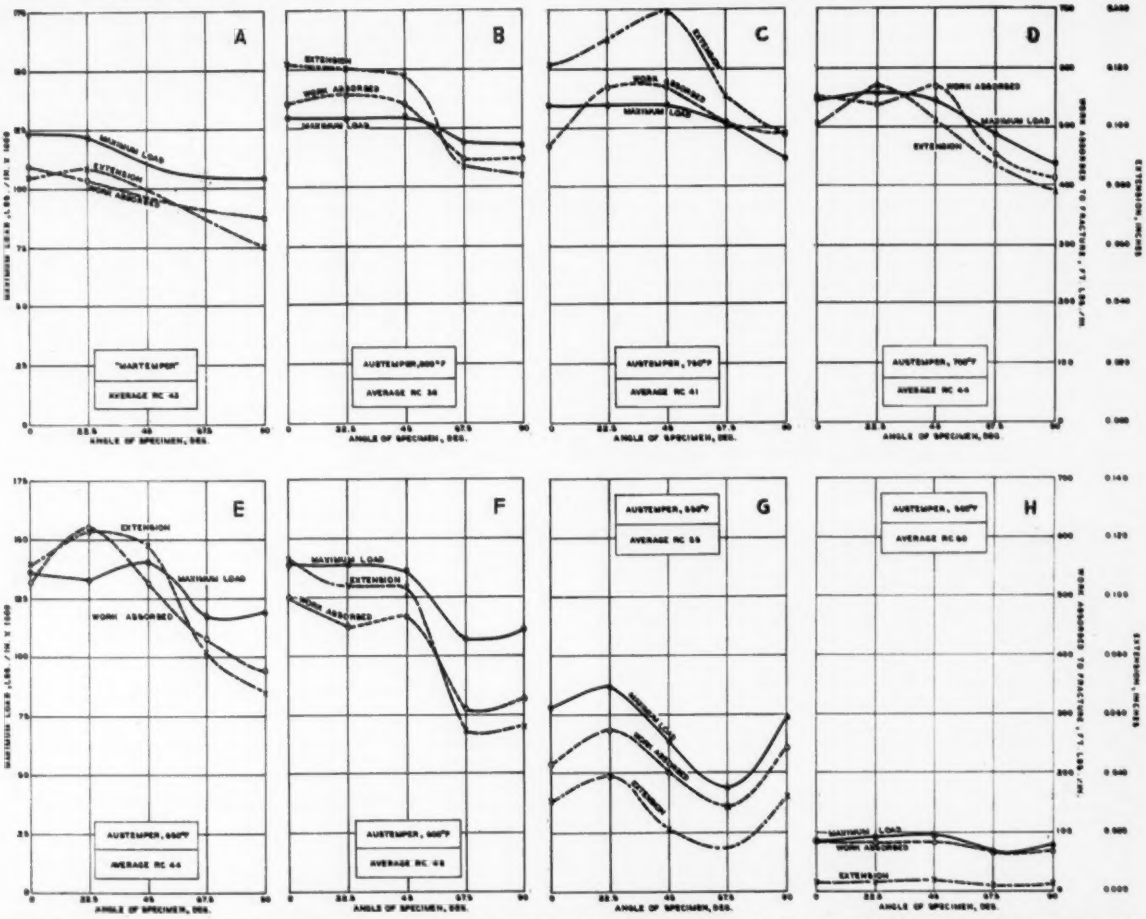


Fig. 12—Navy tear test properties and average hardness of straight-rolled C-1085 strip steel. A, hardened-and-tempered; B-H, austempered 800°-500° F.

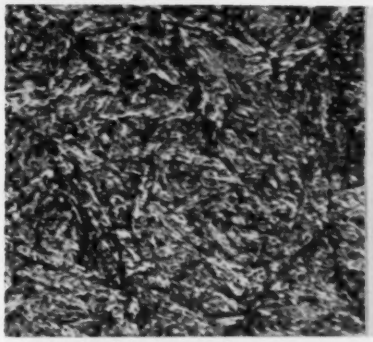
Sixteen-inch disks of BWG 12 C-1085 straight-rolled strip steel were then austempered at 650°, 700°, and 735° F for 5 minutes holding time. Hardness and microstructures obtained were similar to those resulting from the laboratory tests, and ball-test fractures were completely nondirectional. Unquestionably, harrow disks of nondirectional fracture characteristics and good physical properties could be made from straight-rolled C-1085 commercial-quality strip steel by austempering.

I had resigned from the International Harvester Company before the spring of 1955 at which time field tests

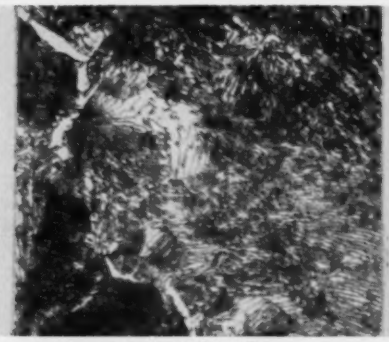
Today, at the Hamilton Works of the International Harvester of Canada, the disk line turns a piece of straight-rolled steel into a disk in about an hour. The material is blanked out, preheated, stamped, edge-rolled, formed, austempered, acid-cleaned, and phosphated on an automated line, which produces the disks at the rate of 450 an hour—about a million a year. The austempering temperature is at the same 750° F which first gave us good laboratory results.

I can't conclude this article without a word of thanks to the many people who helped to make that idea grow. • • •

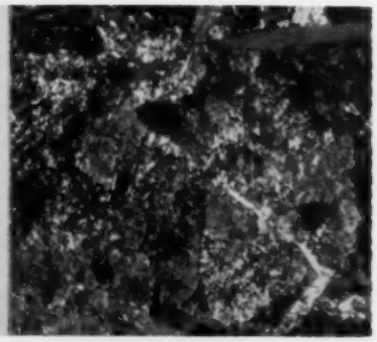
Fig. 13—Microstructure and hardness of straight-rolled C-1085 strip steel. (a), Hardened-and-tempered; (b)-(l), Austempered 1150°-500° F. Etchant 4% picral; 1000x.



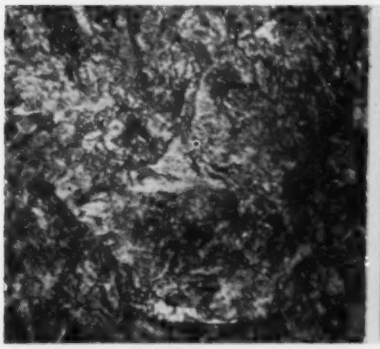
(a) Hardened-and-tempered. Tempered martensite RC 38-43.



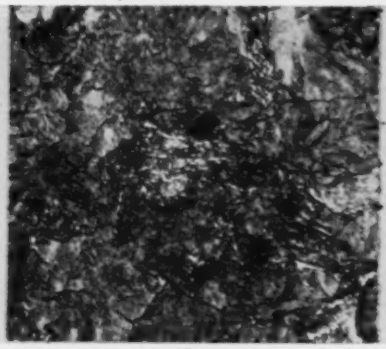
(b) Austempered 1150°-1100° F. Fine to coarse pearlite, some grain-boundary ferrite. RC 20-30.



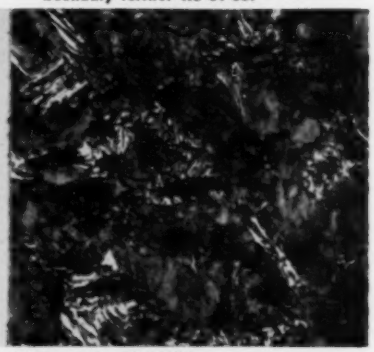
(c) Austempered 1050° F. Very fine to coarse pearlite, traces grain-boundary ferrite. RC 31-33.



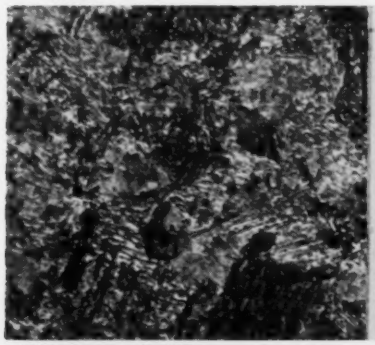
(d) Austempered 950° F. Very fine pearlite, trace bainite. RC 34-37.



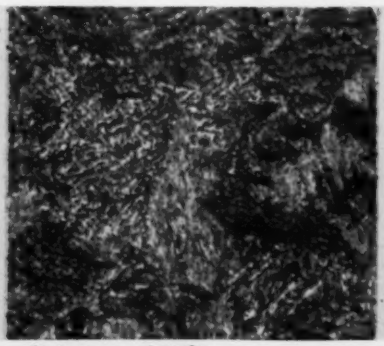
(e) Austempered 850° F. Very fine pearlite, increasing bainite. RC 34-40.



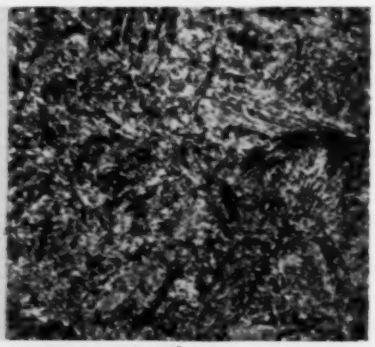
(f) Austempered 800° F. Very fine pearlite, bainite. RC 37-40.



(g) Austempered 750° F. Bainite, some very fine pearlite. RC 38-42.

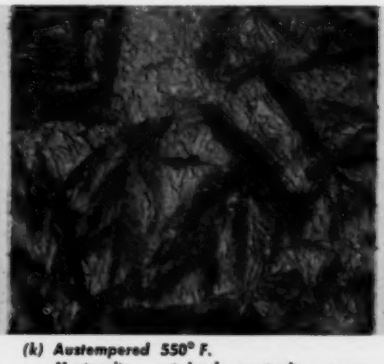


(h) Austempered 700° F. Bainite. RC 41-45

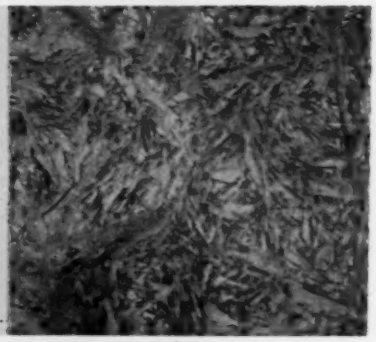


(i) Austempered 650° F. Bainite. RC 42-46.

(j) Austempered 600° F. Acicular bainite, martensite, retained austenite. RC 46-51.



(k) Austempered 550° F. Martensite, retained austenite, some acicular bainite. RC 54-57.



(l) Austempered 500° F. Martensite, retained austenite, traces of acicular bainite. RC 59-62.

NEWS TO HEAT TREATERS

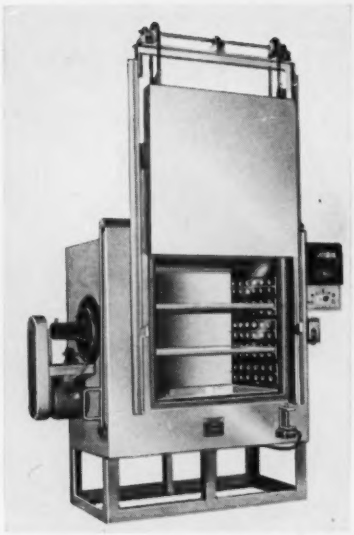
(Continued from page 36)

Ordnance Missile Command, Redstone Arsenal, Alabama. An appraisal of mineral resources for the future will be presented by Royce Hardy, U.S. Assistant Secretary of Interior. Among other highlights of the Conference will be an address by National ASM President, Clarence H. Lorig of Battelle Memorial Institute, and a tour of the Atomic Energy Commission's Savannah River Plant, one of the largest U.S. installations devoted to the production of nuclear materials.

ELECTRONIC PROPORTIONING CONTROL SYSTEM

Modern demands have precipitated the design and manufacture of these large capacity, higher temperature range recirculating ovens, ideally suited for preheating, stress relieving, forming techniques and heat treating alloys such as magnesium, aluminum, titanium or other newer alloys. Meets Air Force Spec. MIL-H-6088A.

One outstanding feature of TEMP-O-LOY Ovens is Blue M Electric Company's exclusive Proportioning Control System. External



thermocouple resistance is automatically proportioned and control pointer shifted closer to point of actuation. Incorporated with 3-step power selection and horizontal air flow distribution, this new electronic system provides performance equal to that resulting from expensive potentiometer instrumentation.

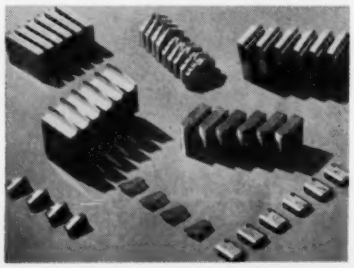
For further information circle No. 5

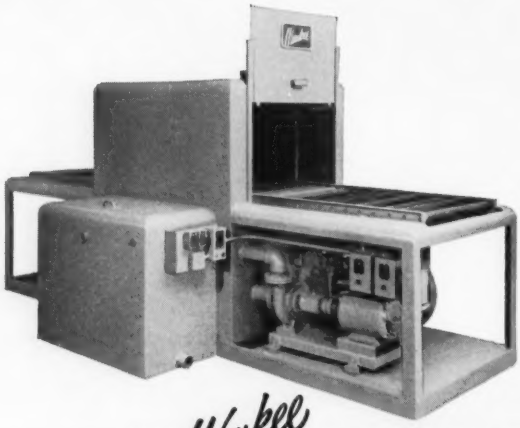
SURFACE HARDENING CHEMICAL BATH

A preventive measure minimizing failure of high-speed cutting tools has been made available by The A. F. Holden Co. in the form of a surface hardening neutral bath of properly selected chemicals. Known as the Hy-Speed Case process, it is being used by industry to maintain maximum output schedules on long production runs.

The bath is used to give greater wear resistance and increased surface hardness to high-speed steels and high-carbon, high-chrome type alloys after they have been hardened, tempered and ground. This

(Continued on page 52)





There's a standard Waukee® WASHER
TO MATCH YOUR CARBONITRIDER OR CARBURIZER!

Whatever the size of your carbonitrider or carburizer, the new Waukee Washer has a standard size to match it. Size range: 24 x 36 x 18 — 24 x 48 x 24 — 30 x 48 x 24 — 36 x 48 x 24.

COMPLETE — NO "EXTRAS" — Waukee parts washers come to you complete, ready to locate, connect to utilities, and begin operation. No "extras" to buy and install. Pumps, burners, controls are designed as integral parts of the Waukee Washer. You use your present furnace work-baskets, too.

FLEXIBILITY — You gain in flexibility with Waukee Washers. Standard units are available in "in-and-out" feed or straight-through, conveyor type, and in one, two, or three stages with rinse and dry. High-efficiency with gas, electricity, or steam.

THOROUGH CLEANING — The smallest Waukee Washer sprays a minimum of *one ton of hot detergent solution through the load each minute.* Solution penetrates work basket from top and bottom, washes away oil and foreign matter from the densest charge. Bull's-eye timer cycles the load for complete washing without guesswork or waste of time.

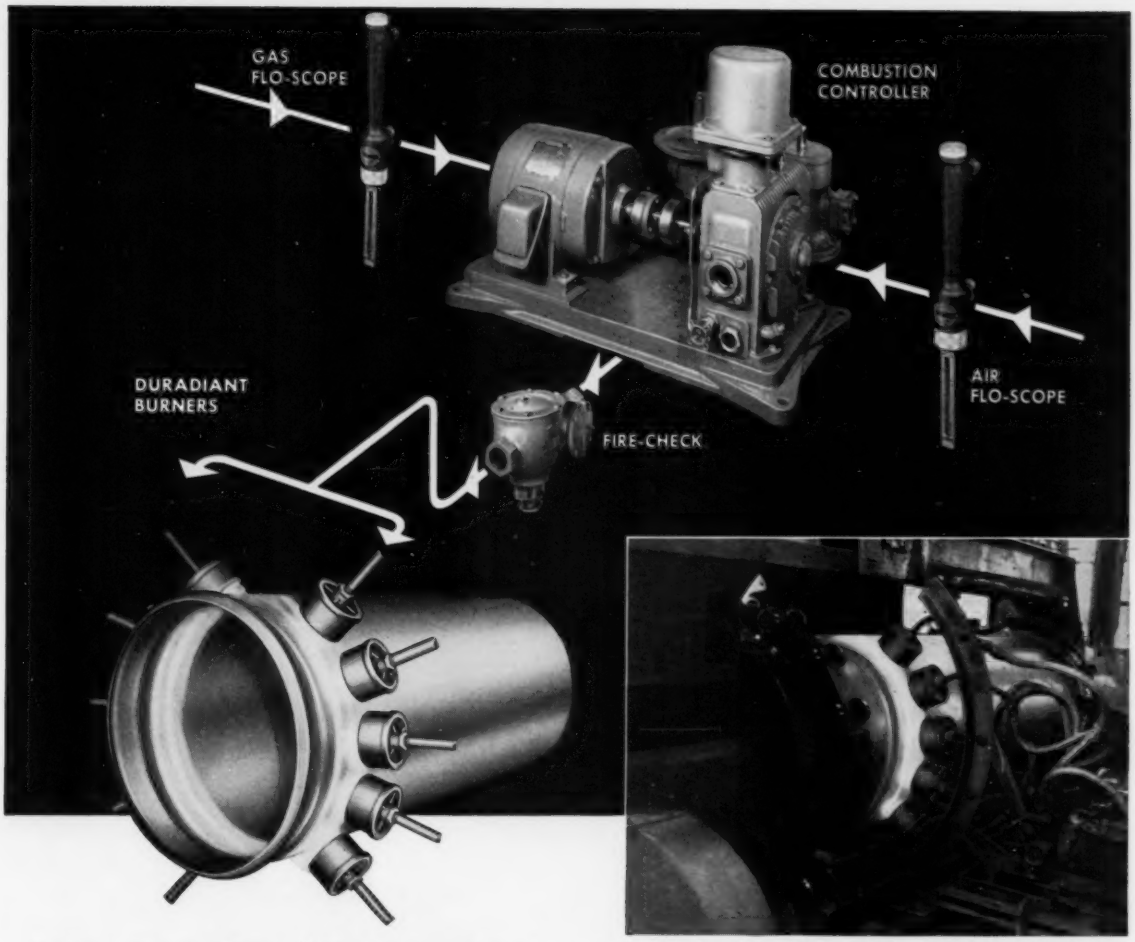
Complete data in Bulletin 1201 — write for it today.

Waukee-washed parts are free of cutting and quenching oils, mean clean furnace atmospheres, therefore predictable case depths and cleaner, brighter work.

Waukee ENGINEERING CO.

5137 N. 35TH ST., MILWAUKEE 9, WIS.

MAKERS OF WAUKEE GAS FLO-METERS • MIXORS • COMPRESSORS



Steel furnace shell, 8 ft long, rotates while a 6 in. wide band is heated to 1500°F for corrugating. Ten Duradiant burners, five on each side of workpiece, beam high intensity radiant energy without flame impingement; cut heating time in half.

Selas Duradiant® Burners heat furnace shells for corrugating . . . double production rate

Boiler Engineering Company, Phoenixville, Pa., corrugates the heavy steel furnace shells used in its line of Continental Automatic Boilers to add strength and increase working safety.

Use of Selas Duradiant gas burners . . . which direct controllable, fast radiant heat to selective areas of each steel furnace shell prior to corrugating . . . has doubled production rate and cut fuel costs by 75%.

To assure most efficient operation of these Duradiant burners, Boiler Engineering Company uses this complete Selas combustion package:

- Combustion Controller—makes possible fast heating and close control, by delivering gas-air mixture to burners at preset ratio and pressure. Completely automatic; no labor required in its operation. Factory Mutual approved.
- Flo-Scopes®—installed at the inlets to the Combustion Controller, Flo-Scopes measure rates of flow of gas and air and permit accurate determination of gas-air mixture ratios.
- Fire-Check—gives complete assurance of safety by automatically extinguishing any flashbacks that may occur. Factory Mutual approved.

Standard Duradiant burners can be utilized in open arrangements . . . in-line . . . in circular rings . . . in spirals . . . individually . . . in opposed pairs. Special Duradiant designs can be custom-built to meet your specific needs.

Selas also offers other types of burners including Superheat, Refrak, Spear-Flame and Ribbon.

These combustion components are available individually or as a complete combustion package.

For descriptive literature on any of the above combustion components, write Dept. 63, Selas Corporation of America, Dresher, Pa.

Duradiant and Flo-Scope are registered trade names of Selas Corporation of America.

SELAS
CORPORATION OF AMERICA
DRESHER, PENNSYLVANIA

Heat and Fluid Processing Engineers

DEVELOPMENT • DESIGN • CONSTRUCTION

Worker lowers Inconel hood over alloy wire coils for controlled-atmosphere annealing cycle. Hood has had no maintenance through 4 years, shows no visible high-temperature attack. In service at Techalloy Company, Rahns, Pennsylvania.

How to put a hood on costs of controlled-atmosphere annealing

. . . Techalloy does it with a hood of long-lasting Inconel

This Inconel* nickel-chromium alloy hood's been in regular use 4 years. *It's never been repaired* . . . doesn't even *show* high-temperature attack!

The hood, others like it, help Techalloy hold down annealing costs in producing alloy wire and strip to rigid specifications. Hoods hold controlled atmospheres around wire in temperatures up to 1800°F . . . they're often used around the clock. Among alloys processed are Duranickel* age-hardenable nickel, Inconel alloys (including Inconel "X"* age-hardenable nickel-chromium alloy) and Monel* nickel-copper alloy.

Inconel high temperature parts give economical service in many other places around the shop — in muffles, shaker hearths, furnace baskets and radiant tubes. Inconel alloy is readily formed and welded.

Thinking of Inconel equipment to cut your own heat treating costs? Write us for information, telling us your specific needs. *Registered trademark

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

INCO NICKEL ALLOYS

WHAT WOULD YOU DO?

(Continued from page 32)

The Case of the Senior Shear Operator

When the foreman of the midnight shift in a steel fabricating plant walked through the shop one night, he noticed that one of the shear operators had failed to report. He had a heavy schedule to meet and decided that the thing to do was to telephone another operator and let him work a few hours overtime before the start of his regular day shift.

He called a man who lived near the plant. That way, he figured, he would get help in a short time. The trouble was that the shear operator he telephoned didn't happen to be the one with most seniority. This led to a grievance in which it was claimed that the foreman had violated the provision of the union contract which read: "In the distribution of overtime, seniority will be observed within each employee's ability to perform the available work."

The company defended the foreman's action on two grounds: 1) It was an emergency, since the night shift shear operator had given no advance notice that he was going to be out; and 2) Personnel records were locked up during the midnight shift and the foreman didn't have the seniority roster.

Eventually, the case went to arbitration under the Rules of the American Arbitration Association.

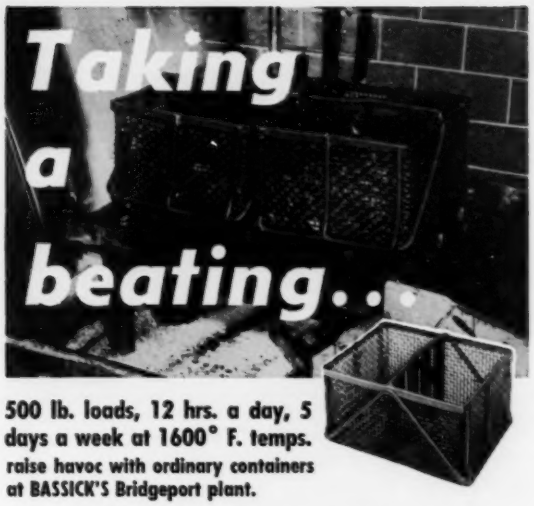
What Would YOU Do?

THE AWARD: The arbitrator gave little weight to the "emergency" angle. What happened was not an emergency within the usual meaning of the word but an ordinary circumstance covered by the seniority and overtime provision. As to the second argument that the night shift foreman didn't have access to the seniority roster, the arbitrator said: "When a commitment is made by an employer, it is incumbent on such an employer to provide supervisors with a reasonable means of carrying out the letter and intent of that provision." He ruled that the company must take the blame for not making the seniority list available to the night shift foreman.

CAUTION: The award in these cases is not an indication of how other arbitrators might rule in other apparently similar cases.

Here's why you can have confidence in America's future!

Family income after taxes is at an all-time high of $5300—is expected to pass $7000 by 1975. There's a new wave of opportunity coming and smart people are getting ready for it.



500 lb. loads, 12 hrs. a day, 5 days a week at 1600° F. temps. raise havoc with ordinary containers at BASSICK'S Bridgeport plant.

But since changing to WIRETEX BASKETS, life span is three times greater . . . heat temps. extended . . . corrosion ended . . . loads distributed, handled better and faster. Free flow of quenching oil is assured; secondary handling eliminated. BASSICK engineers report increased production, improved quality control, greater savings.
If better heat treating is your problem . . . Call Wiretex. Send for literature.

Specialists in Processing Carriers Since 1932.

Wiretex mfg. co., 16 Mason Street, Bridgeport 5, Conn.

BLUE M
CON-WATE ULTRA-TEMP MECHANICAL CONVECTION OVENS
PATENTS PENDING
150° F. TO 1200° F. (149° C.) RANGE

- HORIZONTAL AIR FLOW
- ELECTRONIC INSTRUMENTATION
- WATTAGE CONTROL
- ALLOY (18-8) INTERIOR

CON-WATE Ultra-Temp automatically compensates for loss of air weight (density) when temperatures are elevated. The CONSTANT AIR WEIGHT feature, exclusively Blue M's, means greater efficiency and faster results. Heating procedures made for less cost.

EXCELLENT UNIFORMITY • QUALITY CONSTRUCTION • READY FOR SERVICE • INSTRUMENTATION AVAILABLE FOR YOUR APPLICATION

For RESEARCH or PRODUCTION at a cost within reach.
For LESS CRITICAL APPLICATIONS, also available in Forced Draft and Gravity Models.

The only oven that prevents "AIR ANEMIA"

BLUE M ELECTRIC CO.
138th AND CHATHAM ST. BLUE ISLAND, ILL.
Manufacturer of ovens, furnaces and related temperature controlled equipment.

MANUFACTURERS' LITERATURE

For your copy circle the number on the Readers' Service Card

X-RAY ANALYSIS THEORY

A new 12-page booklet titled "X-ray Analysis Theory & Instrumentation" is available gratis from the Instruments Division, Philips Electronics, Inc., Mount Vernon, New York.

Text covers principles of operation and uses simple diagrams to illustrate the basic differences between: Film Diffraction, Diffractometry and Spectrography. Illustrated with photos, special sections treat each of the three methods in detail.

Subjects discussed include: Basic Diffraction Unit, Bragg's Law, Diffractometer, Wide Range Goniometer, Electronic Circuit Panel, Counting Rate Computer, Spectrograph Assembly, Scintillation, Proportional and Flow Proportional Detectors, and Geiger Tubes.

Other pages give applications in industry and user lists. In addition, the booklet describes the Autrometer, the automatic indexing X-ray Spectrograph designed for production line work where qualitative and quantitative analyses of as many as 24 elements in a single specimen must be made rapidly.

For further information circle No. 7

MISSILE METAL MACHINING

The Diversey Engineering Co. has published a bulletin entitled *Missile Metal Machining* which explains their large facilities devoted exclusively to solving guided missile and rocket hardware problems. The bulletin maintains that the company has the facilities and skilled experience in contour machining which can help solve your intricate problems.

For further information circle No. 8

DECIMAL CHART

A decimal equivalent chart, with fractional units from 1/64" to 1", is available from the Ohio Seamless Tube Division of Copperweld Steel Company. Equivalents are neatly defined in blue and black for easy reference.

The chart measures 8½" x 11" and is printed on heavy coated white card stock with rounded corners. Punched for convenient wall hanging, it is also suitable for use in standard 3-ring binders.

For further information circle No. 9

HOT OIL QUENCHING

The Sinclair Refining Co. has published a 16-page illustrated technical bulletin entitled *Hot Oil Quenching* explaining the use of their premium oils, Quenchol 524 and Marquenchol, which are designed for elevated temperatures.

The bulletin gives many diagrams and graphs and technical explanations describing the benefits to be derived from hot oil quenching. It is pointed out that many plants are using new special alloy steels in order to meet new and higher requirements and that these steels require hot oil quenching in order to solve the important problem of producing quenched parts which meet the rigid dimensional standards required by machinery designers.

For further information circle No. 10

INSTRUMENTS CATALOG

Tubeless, 'solid-state' controllers, manufactured by West Instrument Corp., are explained in a recently-published bulletin which gives details concerning their "Gardsman" line of temperature controls and accessories.

For further information circle No. 11

BRAIDED CORD FOR HEAT TREATING

Production of a new braided tape and cord used in tieing down or suspending materials in heat treating furnaces has been announced by Fred Strasmich, President of the Ross Matthews Corp., Fall River, Mass.

The new braided cord is basically composed of fiber glass material and is said to outlast other materials such as nylon, wire, and asbestos nearly twenty times. The cord is capable of withstanding high temperatures.

The company is a specialist in the production of braided cord in nylon, fiberglass, etc., and has facilities for custom manufacturing to any specifications.

For further information circle No. 12

INDUCTION HARDENING

A new bulletin published by the Ohio Crankshaft Co. describes the cost savings and increased production rates claimed for their induction hardening and heat treating processes. The bulletin is entitled "Typical Results of Tocco® Induction Hardening and Heat Treating."

For further information circle No. 13

HEATING ELEMENTS

Bulletins describing the Kanthal electric heating elements used in a huge honeycomb brazing furnace have been published by the Kanthal Corp.

The furnaces were built by the Pacific Scientific Co., who selected these Kanthal elements in order to meet specifications to provide close temperature uniformity with fast heating and cooling.

For further information circle No. 14

(Continued on page 53)

"IT'S YOUR PLANT, POP. THEY'RE MISSING SOME SORT OF FURNACE."

How to Cut Pot Costs:

Buy low-cost Eclipse pressed (not welded) steel pots . . . and replace them on a regular schedule. You'll save through:

1 Lower initial cost

2 Elimination of failures

3 Faster, more even heating

4 Quantity discounts earned on your total purchases in any 12-month period

Guaranteed free from defects. Write:

ECLIPSE FUEL ENGINEERING COMPANY
Industrial Combustion Division
1018 Buchanan St., Rockford, Ill.

Eclipse® PRESSED STEEL POTS

Export: Ad Auriema, Inc., 85 Broad St., N.Y.C.

70 years of know-how goes into your Industrial Furnace

Heat treating, melting, testing, forming, ceramic . . . if it's an INDUSTRIAL FURNACE we *make* it. We'll save you money and guarantee you'll be satisfied.

If yours is a special problem, our engineering staff has been solving those for nearly three quarters of a century.

For normal, no-special-problem operations, one of our standard pretested furnaces will give you longer service, at lower over-all cost, than any other unit of its kind on the market.

Semi-Muffle Type
Heat Treating Furnace

DF9-6

DENVER FIRE CLAY COMPANY
3033 Blake Street, Denver, Colorado

Please send Industrial Furnace information.

Name.....

Address.....

City.....

Denver Fire Clay Company
DENVER • SALT LAKE CITY • EL PASO

NEWS TO HEAT TREATERS

(Continued from page 46)

process is said to condition a high-speed tool to its maximum efficiency and productivity after a short period of treatment.

Photo shows high speed steel thread chasers after treatment with the neutral bath.

For further information circle No. 6

INDUSTRIAL FURNACE STATISTICS

Net new orders for industrial furnaces in January 1959 totaled $3,518,000 compared with the 1958 monthly average of $3,694,000. January 1959 new business was up 19 per cent from the January 1958 volume of $3,045,000. Total 1958 billings of $77,784,000 represented a drop of 41 per cent from 1957 billings of $131,827,000. Similarly, the backlog of the industry January 31, 1958, totaled $44,597,000 as compared with 1957 year and backlog of $73,571,000.

Exports of industrial furnaces rose substantially to $7,151,000 in 1958 from $2,880,000 during 1957. Since both domestic and foreign business are on the increase, it is anticipated that the upward trend in the furnace industry will continue during 1959.

January 1959 net orders for induction heating equipment of $1,004,000 were higher than any previous month since August 1957, and were up 60 per cent over the January 1958 volume when only $630,000 of new orders were booked. Billings for 1958 totaled $12,034,000, down $5,450,000 from the preceding year.

Net new orders in the last half of 1958 were $3,727,000, up 28 per cent from the first half 1958 volume of $2,915,000. Exports of induction heating equipment in 1958 rose to $2,029,000 from $841,000 in 1957, an increase of 141 per cent. These figures have been released by the Industrial Heating Equipment Association, Inc. in Washington, D.C.

NEW LIQUID SALT REMOVER

A new liquid product, known as No Bleed, for removing entrapped or absorbed blackening salts from powdered metal parts has been developed by Heatbath Corp., Springfield, Mass. No Bleed eliminates or insures against such conditions as bleeding, blooming, flowering and weeping out that become visible and are objectionable on blackened powdered metal parts.

It is used as received at a temperature of 240-250°F for 15-30 minutes. The powdered metal parts are then allowed to dry and are eventually re-oiled.

For further information circle No. 15

VACUUM LEAK DETECTOR

General Electric's new Type H-4 Halogen Vacuum Leak Detector has been successfully used in a vacuum application previously reserved for the super-sensitive mass spectrometer leak detector.

This versatility of the H-4 was recently demonstrated at the High Vacuum Equipment Corporation, Hingham, Massachusetts, where it was used to supplement the mass spectrometer leak detector in testing a vacuum brazing furnace used for brazing jet engine component parts.

The H-4, with a sensitivity of 10^{-6}xcc/sec., successfully leak-tested the high temperature, internally heated furnace which is designed to operate at 2500°F at a vacuum of 5×10^{-5}mm Hg.

In leak testing vacuum equipment, the probe of the leak detector is installed in the vessel to detect the presence of halogen vapors while the entire vessel is carefully sprayed with a halogen tracer gas. If the tracer gas passes over a leak, some of the gas will enter the vacuum system and surround the halogen sensitive element, causing a leak signal on the indicating instrument and audible alarm located on the control panel.

For further information circle No. 16

POCKET-SIZE MEASURING MICROSCOPE

The Micro-Mike, a twenty-power, pocket-size inspection and measuring microscope having a superimposed scale, is announced by the DuMaurier Company of Elmira, N. Y., manufacturers of industrial pocket microscopes and other optical products.

An accurate, four-lens optical system, contained in a lightweight metal casing provides a flat, undistorted field which is larger and brighter than any other instrument of this type. The superimposed scale, with .002 inch graduations, is internal and cannot be scratched or smeared. No adjustments are needed and no skill is required—"just focus and read".

Inexpensively priced, the Micro-Mike is capable of performing many tasks formerly accomplished only by elaborate and expensive laboratory-type equipment. Adaptable to all phases of industry, it permits easy, accurate inspection and measurement of tiny parts, as well as measurement of fine lines, screens, meshes, fabrics and other surfaces where micrometers cannot be used.

For further information cirle No. 17

FOR SALE

GLEASON #26 QUENCHING PRESS
Condition — Like New
Flat Dies and Center Expander with Machine.
Equipped for Oil or Water Quenching
Capacity to 25" Diameter

Priced for Quick Sale

WRITE TO—

UNION SPRING AND MFG. COMPANY
NEW KENSINGTON, PA.

MANUFACTURERS' LITERATURE

(Continued from page 50)

HEAT TREATING ARTICLES

The Ajax Electric Company has announced the availability of reprints of articles dealing with various heat treating processes.

Please circle the item number for the ones in which you are interested on the Readers' Service Card:

"Aluminum Dip Coated on Steel Parts," by R. F. Joy, *Circle No. 18.*

"Salt Bath Brazing," by L. B. Rosseau, *Circle No. 19.*

"Dip Brazing of Aluminum Pays with Accurate Assemblies," by E. G. Slotta, *Circle No. 20.*

"High Penetration Produces High Strength Brazed Joints," by J. W. Maston, *Circle No. 21.*

PATENT INFORMATION

A time-saving patent reference that lists all important information referring to any given patent is now being published in a new publication called *Patent-Dex Reporter.*

Today's busy executive does not have the time to browse through hundreds of patents, drawings, legal talk and descriptions until he comes to the pertinent data he desires. The new publication is indexed to give factual patent information instantaneously.

Patent-Dex Reporter is issued weekly, right after the Government's release of patent data. One line tells the story . . . The Class, The Patent Number, The Invention, The Inventor, The Company it was assigned to and the date it was issued. A person can immediately see what is being patented, the companies participating, the inventors and how many patents are being issued weekly in any given class.

Overnight, a new patent can make thousands of hours of engineering and research obsolete. A new invention could change the whole approach to an important project. In the final analysis keeping yourself and your company up to date on patent developments could effect a considerable saving in time and money. A complete issue will be sent for examination.

For further information circle No. 22

FLAME HEATING BULLETIN

A leaflet describing its line of Flamatic Precision Selective Flame Heating Machines designed especially for heating applications requiring extremely high or low heating capacity as well as precise temperature control is available from Cincinnati Milling Machine Co.

In addition, specifications as well as cross-section diagram and clearly-listed design highlights are given.

For further information circle No. 23

CUTTING HEAT TREATING COSTS

A booklet, *Heat Treat Review,* with an article on cutting heat treating costs, is now available from Surface Combustion Corp. Included is a discussion of furnace design, specification of product material, selection of processes relative to cost, as well as the question of economics in selecting heat treating equipment. Also there is an article on equipment used by one of the largest screw manufacturing plants.

For further information circle No. 24

TECHNICAL BOOKS

Technological developments taking place today in many manufacturing industries have created the problem of the effective use of industrial improvements and innovations requiring the rapid training of large numbers of highly-skilled tradesmen, technicians, and engineers.

Two recently published American Technical Society books were prepared with these industrial training requirements in mind: *Manufacturing Processes-Production* ($7.25) and *Mathematics for Industry* ($6.25) by S. E. Rusinoff, Professor of Mechanical Engineering, Illinois Institute of Technology.

The former was recently revised and enlarged and is extensively illustrated to fill the need for a comprehensive study of the machinery employed in the fabrication of metal parts. *Mathematics for Industry* is a functional presentation of the math most often needed in engineering and machine shops.

For further information circle No. 25

FREE MARKAL PAINTSTIK!

We will send you without cost or obligation a MARKAL PAINTSTIK. They are available in various types suitable for marking on any kind of material. Hot surfaces up to 2100°F, also welding and heat treating. Cold surfaces down to −50°F, wet, dry, icy, oily, rough, smooth, acid or alkali. ***MARKS Are Permanent, Fadeproof, Weatherproof.*** Specify surface condition, material, temperature at time of marking.

USE THIS COUPON OR WRITE ON YOUR LETTERHEAD!

Here's what I want to mark: _____

_____

_____

_____

_____ Marking Temperature _____ Max. Temp. _____ °F.

Name _____

Company _____

Address _____

City _____ Zone _____ State _____

My Distributor's Name _____

MARKAL COMPANY 3102 West Carroll Avenue • Chicago 12, Illinois

METAL TREATING

EQUIPMENT and MATERIALS DIRECTORY

AMMONIA, ANHYDROUS

ARMOUR AMMONIA DIVISION
1355 West 31st Street
Chicago, Illinois

AMMONIA STORAGE EQUIPMENT

ARMOUR AMMONIA DIVISION
1355 West 31st Street
Chicago, Illinois

C. I. HAYES, INC.
816 Wellington Avenue
Cranston 10, Rhode Island

CARBURIZING COMPOUNDS

PARK CHEMICAL COMPANY
8074 Military Avenue
Detroit 4, Michigan

FABRICATION
(Heat & Corrosion Resistant)

ALUMINUM AND ARCHITECTURAL METALS COMPANY
1974 Franklin Street
Detroit 7, Michigan

BLAW-KNOX COMPANY
NATIONAL ALLOY DIVISION
Pittsburgh 38, Pennsylvania

ECLIPSE FUEL ENGINEERING CO.
1018 Buchanan Street
Rockford, Illinois

IPSEN INDUSTRIES, INC.
715 South Main Street
Rockford, Illinois

ROLOCK, INC.
1232 Kings Highway
Fairfield, Connecticut

STANWOOD CORPORATION
4825 West Cortland Street
Chicago 39, Illinois

WIRETEX MFG. CO., INC.
16 Mason Street
Bridgeport 5, Connecticut

FIXTURES

AJAX ELECTRIC COMPANY
940 Frankford Avenue
Philadelphia 23, Pennsylvania

ALUMINUM AND ARCHITECTURAL METALS COMPANY
1974 Franklin Street
Detroit 7, Michigan

ECLIPSE FUEL ENGINEERING CO.
1018 Buchanan Street
Rockford, Illinois

INTERNATIONAL NICKEL CO., INC
67 Wall Street
New York 5, New York

ROLOCK, INC.
1232 Kings Highway
Fairfield, Connecticut

STANWOOD CORPORATION
4825 West Cortland Street
Chicago 39, Illinois

WIRETEX MFG. CO., INC.
16 Mason Street
Bridgeport 5, Connecticut

FLAME HARDENING

META-DYNAMICS DIVISION
THE CINCINNATI MILLING MACHINE COMPANY
4701 Marburg Avenue
Cincinnati 9, Ohio

SELAS CORPORATION OF AMERICA
Dresher, Pennsylvania

FLOW MEASUREMENT

AMERICAN GAS FURNACE CO.
808 Lafayette Street
Elizabeth, New Jersey

SELAS CORPORATION OF AMERICA
Dresher, Pennsylvania

WAUKEE ENGINEERING CO.
5137 North 35th Street
Milwaukee 9, Wisconsin

FURNACES

AMERICAN GAS FURNACE CO.
808 Lafayette Street
Elizabeth, New Jersey

BLUE M ELECTRIC COMPANY
138th and Chatham Street
Blue Island, Ilinois

ECLIPSE FUEL ENGINEERING CO.
1018 Buchanan Street
Rockford, Illinois

C. I. HAYES, INC.
816 Wellington Avenue
Cranston 10, Rhode Island

HEVI-DUTY ELECTRIC CO.
P. O. Box 563
Milwaukee 1, Wisconsin

THE A. F. HOLDEN COMPANY
14341 Schaefer Highway
Detroit 27, Michigan

CHARLES A. HONES, INC.
Baldwin, L. I., N. Y.

IPSEN INDUSTRIES, INC.
715 South Main Street
Rockford, Illinois

LINDBERG ENGINEERING COMPANY
2466 West Hubbard Street
Chicago 12, Illinois

PACIFIC SCIENTIFIC COMPANY
P. O. Box 22019
Los Angeles 22, California

SELAS CORPORATION OF AMERICA
Dresher, Pennsylvania

FURNACES (Salt Bath)

AJAX ELECTRIC COMPANY
940 Frankford Avenue
Philadelphia 23, Pennsylvania

AMERICAN GAS FURNACE CO.
808 Lafayette Street
Elizabeth, New Jersey

ECLIPSE FUEL ENGINEERING CO.
1018 Buchanan Street
Rockford, Illinois

HEVI-DUTY ELECTRIC CO.
P. O. Box 563
Milwaukee 1, Wisconsin

THE A. F. HOLDEN COMPANY
14341 Schaefer Highway
Detroit 27, Michigan

CHARLES A. HONES, INC.
Baldwin, L. I., N. Y.

LINDBERG ENGINEERING COMPANY
2466 West Hubbard Street
Chicago 12, Illinois

FURNACES (Vacuum)

C. I. HAYES, INC.
816 Wellington Avenue
Cranston 10, Rhode Island

HEVI-DUTY ELECTRIC CO.
P. O. Box 563
Milwaukee 1, Wisconsin

IPSEN INDUSTRIES, INC.
715 South Main Street
Rockford, Illinois

LINDBERG ENGINEERING COMPANY
2466 West Hubbard Street
Chicago 12, Illinois

NEW YORK AIR BRAKE COMPANY
KINNEY MFG. DIVISION
3594 D Washington Street
Boston 30, Massachusetts

PACIFIC SCIENTIFIC COMPANY
P. O. Box 22019
Los Angeles 22, California

GAS BURNERS & TORCHES

CHARLES A. HONES, INC.
Baldwin, L. I., N. Y.

GAS GENERATORS

AMERICAN GAS FURNACE CO.
808 Lafayette Street
Elizabeth, New Jersey

EQUIPMENT AND MATERIALS DIRECTORY *(Continued)*

C. I. HAYES, INC.
816 Wellington Avenue
Cranston 10, Rhode Island

HEVI-DUTY ELECTRIC CO.
P. O. Box 563
Milwaukee 1, Wisconsin

IPSEN INDUSTRIES, INC.
715 South Main Street
Rockford, Illinois

LINDBERG ENGINEERING COMPANY
2466 West Hubbard Street
Chicago 12, Illinois

PACIFIC SCIENTIFIC COMPANY
P. O. Box 22019
Los Angeles 22, California

GAS MIXING EQUIPMENT

WAUKEE ENGINEERING CO.
5137 North 35th Street
Milwaukee 9, Wisconsin

GASES

ARMOUR AMMONIA DIVISION
1355 West 31st Street
Chicago, Illinois

HARDNESS TESTERS

WILSON MECHANICAL INSTRUMENT DIV.
AMERICAN CHAIN & CABLE COMPANY, INC.
230 Park Avenue
New York 17, New York

STEEL CITY TESTING MACHINES, INC.
8805 Lyndon Avenue
Detroit 38, Michigan

HEATING ELEMENTS (Non-Metallic)

NORTON COMPANY
622 New Bond Street
Worcester 6, Massachusetts

HIGH TEMPERATURE FANS

GARDEN CITY FAN COMPANY
801 North Eighth Street
Niles, Michigan

INDUCTION HARDENING

META-DYNAMICS DIVISION
THE CINCINNATI MILLING
MACHINE COMPANY
4701 Marburg Avenue
Cincinnati 9, Ohio

METAL FINISHING

HEATBATH CORPORATION
P. O. Box 78
Springfield 1, Massachusetts

THE A. F. HOLDEN COMPANY
14341 Schaefer Highway
Detroit 27, Michigan

NITRIDING

THE A. F. HOLDEN COMPANY
14341 Schaefer Highway
Detroit 27, Michigan

OVENS

BLUE M ELECTRIC COMPANY
138th and Chatham Street
Blue Island, Illinois

PROTECTIVE COATINGS

MARKAL COMPANY
3102 W. Carroll Avenue
Chicago 12, Illinois

PARK CHEMICAL COMPANY
8074 Military Avenue
Detroit 4, Michigan

QUENCHING OILS

THE A. F. HOLDEN COMPANY
14341 Schaefer Highway
Detroit 27, Michigan

E. F. HOUGHTON & CO.
303 West Lehigh Avenue
Philadelphia 33, Pennsylvania

PARK CHEMICAL COMPANY
8074 Military Avenue
Detroit 4, Michigan

SINCLAIR REFINING COMPANY
600 Fifth Avenue
New York, New York

REFRACTORIES

NORTON COMPANY
622 New Bond Street
Worcester 6, Massachusetts

SALTS (Heat Treating)

AMERICAN CYANAMID COMPANY
PROCESS CHEMICALS DEPARTMENT
30 Rockefeller Plaza
New York 20, New York

HEATBATH CORPORATION
P. O. Box 78
Springfield 1, Massachusetts

THE A. F. HOLDEN CO.
14341 Schaefer Highway
Detroit 27, Michigan

E. F. HOUGHTON & CO.
303 West Lehigh Avenue
Philadelphia 33, Pennsylvania

PARK CHEMICAL COMPANY
8074 Military Avenue
Detroit 4, Michigan

SPECIAL CONTROL EQUIPMENT

AJAX ELECTRIC COMPANY
940 Frankford Avenue
Philadelphia 23, Pennsylvania

IPSEN INDUSTRIES, INC.
715 South Main Street
Rockford, Illinois

STRAIGHTENING EQUIPMENT

BLAW-KNOX COMPANY
NATIONAL ALLOY DIVISION
Pittsburgh 38, Pennsylvania

GENERAL MANUFACTURING COMPANY
6426 Farnsworth Avenue
Detroit 11, Michigan

TEMPERATURE CONTROLS

BLUE M ELECTRIC COMPANY
138th and Chatham Street
Blue Island, Illinois

MARKAL COMPANY
3102 West Carroll Avenue
Chicago 12, Illinois

WEST INSTRUMENT CORPORATION
4363 West Montrose
Chicago 41, Illinois

TESTING EQUIPMENT

BLUE M ELECTRIC COMPANY
138th and Chatham Street
Blue Island, Illinois

PACIFIC SCIENTIFIC COMPANY
P. O. Box 22019
Los Angeles 22, California

RIEHLE TESTING MACHINES DIVISION
AMERICAN MACHINE AND METALS, INC.
East Moline, Illinois

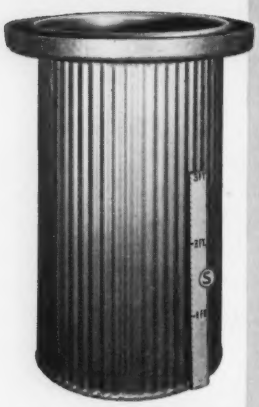
STEEL CITY TESTING MACHINES, INC.
8805 Lyndon Avenue
Detroit 38, Michigan

WILSON MECHANICAL INSTRUMENT DIV.
AMERICAN CHAIN & CABLE COMPANY, INC.
230 Park Avenue
New York 17, New York

TOOL STEELS

BETHLEHEM STEEL COMPANY
Bethlehem, Pennsylvania

COR-WAL RETORT



choose from the most complete line

OF BASKETS, TRAYS, FIXTURES, RETORTS, CARBURIZING BOXES, POTS.

STANWOOD FIXTURE

Through serving commercial heat treaters and heat treating departments all over the U.S. for many years Stanwood has developed the most complete line of heat treating equipment. We can make fast delivery with maximum economy. If you require a special container, fixture or furnace part for which we do not have patterns our engineers can quickly develop and submit a design to meet your requirements. Send for catalog.

Sales Representatives in Principal Cities.

CARBURIZING BOXES

POTS

MUFFLES

TRAYS

BASKETS

STANWOOD CORPORATION

HEAT TREATING EQUIPMENT

4625 W. CORTLAND ST — CHICAGO 39, ILL.

Index To Advertisers

Advertiser	Page
Ajax Electric Company Agency—The Harry P. Bridge Company	Outside Back Cover
Aluminum and Architectural Metals Company Agency—L. Charles Lussier, Inc.	24
American Cyanamid Company (Process Chemicals Dept.) Agency—Hazard Advertising Company, Inc.	15
American Gas Furnace Company Agency—Advent Associates, Inc.	Inside Back Cover
Armour Ammonia Division Agency—Foote, Cone & Belding	34
Bethlehem Steel Company Agency—Jones, Brakeley, & Rockwell, Inc.	27
Blaw-Knox Company Agency—Ketchum, MacLeod & Grove, Inc.	35
Blue M Electric Company Agency—I. A. Feinstein Advertising	49
Cincinnati Milling Machine Co., The (Meta-Dynamics Division) Agency—The Keelor & Stites Co.	23
Denver Fire Clay Company Agency—Harold Walter Clark, Inc.	51
Eclipse Fuel Engineering Company Agency—Howard H. Monk & Associates	51
Garden City Fan Company Agency—The L. W. Ramsey Co.	32
C. I. Hayes, Inc. Agency—Horton, Church & Goff, Inc.	25
Hevi-Duty Electric Company Agency—Bert S. Gittins Advertising	41
Holden Company, The A. F. Agency—	Inside Front Cover
Charles A. Hones, Inc. Agency—Beecher Associates	36
Houghton & Co., The E. F. Agency—Beaumont, Heller & Sperling, Inc.	21
International Nickel Company Agency—Marschalk and Pratt	48
Ipsen Industries, Inc. Agency—Fensholt Advertising Agency	14
Kinney Mfg. Division New York Air Brake Co., The Agency—Humbert & Jones, Inc.	39
Lindberg Engineering Company Agency—Don Colvin & Company, Inc.	19
Markal Company Agency—Paul J. Steffen Company	36, 53
Metal Treating Institute	28-29
New York Air Brake Co., The Agency—Humbert & Jones, Inc.	39
Norton Company, The Agency—James Thomas Chirurg Company	37
Pacific Scientific Company Agency—The Martin R. Klitten Company, Inc.	33
Park Chemical Company Agency—Marvin Hahn, Inc.	38
Rolock, Inc. Agency—The Edward W. Robotham Company	22
Seles Corporation of America Agency—Bub Advertising, Inc.	47
Sinclair Refining Company Agency—Geyer, Morey, Madden & Ballard, Inc.	31
Stanwood Corporation Agency—Tri-State Advertising Company, Inc.	56
Steel City Testing Machines, Inc. Agency—Denham & Company	26
Waukee Engineering Company Agency—John Trytten Advertising	46
Wilson Mechanical Instrument Div. American Chain & Cable Co., Inc. Agency—Reincke, Meyer & Finn	20
Wiretex Manufacturing Company, Inc. Agency—Bass & Company, Inc.	49

Braze and Anneal at operating temperatures from 400°F to 2150°F

Model 88 Bell Retort Furnace.

AGF'S BELL RETORT FURNACES

Removable bell retorts containing work pieces are heated within a cylindrical furnace, as a low dew-point, dry hydrogen or cracked ammonia atmosphere is maintained.

The completely new combustion system provides uniform heating at operating temperatures from 400° to 2150° F.

For:

Bright Copper Brazing of stainless and regular steel.

Nickel-Chromium Alloy Brazing of stainless up to 2150° F.

Bright Annealing of Stainless Alloy, ferrous and non-ferrous materials.

Hydrogen Cleaning or reduction of chromium oxides on stainless.

Without modification, versatile Bell Retort Furnaces can also be employed for nitriding, carburizing and ammonia-gas case hardening.

Semi-continuous operation with multiple bell retorts . . . One bell retort is heated . . . another cools under atmosphere protection . . . and a third is loaded.

Removable bell retorts eliminate cleaning, conditioning and decontaminating of a fixed muffle.

Model 239 Bell Retort Furnace. Box shaped car type retort.

AGF'S CAR TYPE BELL RETORT FURNACES

Designed to meet the need for large capacity batch type stainless processing . . . for handling unusually shaped pieces or heavy work loads. Box shaped bell retort is rolled into and withdrawn from the furnace by means of a chain driven mechanism.
Bell Retort cover is easily removed for loading and unloading.

Rapid and efficient heating is obtained because the bell retort is charged into a hot furnace.

AMERICAN GAS FURNACE CO.

808 LAFAYETTE STREET — ELIZABETH 4, N. J.

"The Standard of the Industry Since 1878"

There are cheaper ways to heat treat metals . . .

BUT NOT WHERE YOU NEED *Precision* RESULTS

ON A MASS PRODUCTION BASIS!

When heat treating requirements are not in the least critical, there are probably cheaper ways you can handle them than in salt. But when highly precise results must be obtained—economically, with a minimum of labor cost—then salt baths offer possibilities that cannot be overlooked.

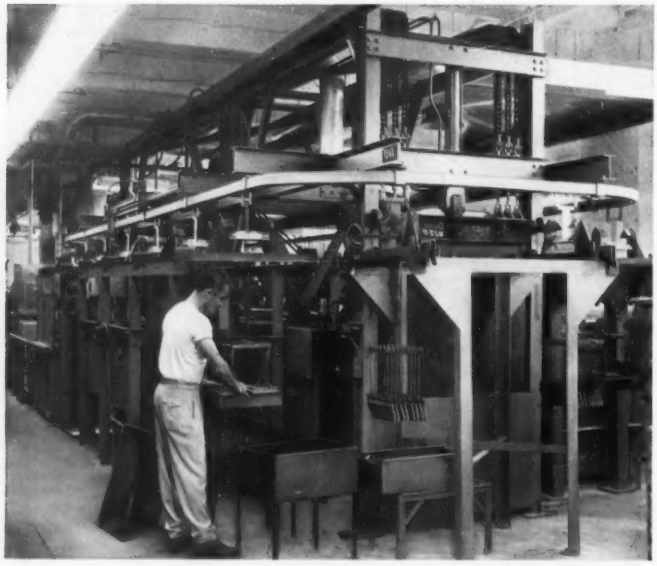
It is now common practice to handle on a salt bath mass-production basis, heat treating so ultra-precise that it may have been regarded as a laboratory method not many years ago.

Moreover, extending far beyond their obvious advantages in hardening steels, salt baths have "come of age" in many different directions.

These range from isothermal processing to heating for forging; from aluminizing to various types of brazing including aluminum and magnesium brazing; from simultaneous carburizing and brazing to heat transfer applications and others which cannot yet be discussed.

Metal fabricators long ago learned to come to Ajax, not merely to buy furnaces, but to enlist specialized heat treating and metallurgical help in solving specific problems; or in improving, economizing or modernizing specific heat treating processes. This has brought Ajax in close association with heat treating requirements, trends, procedures and possibilities over a broad front.

In numerous instances, it has made the ultimate purchase of Ajax equipment incidental to establishing new and better ways of doing things; or of handling critical heat treating jobs to new, higher standards of precision, quality, and economy.



MECHANIZED AUSTEMPERING—Typical of the trend toward salt bath mechanization, this Ajax installation in the Hartford, Conn. plants of the Royal McBee Corporation austempers type bars. It has materially increased production, saved time and improved quality of the parts.

AJAX

HULTGREN

SALT BATH FURNACES

Internally heated electric and gas-fired types

The most efficient heat treating principle for a wide variety of work . . . Pioneered by Ajax in the largest line of furnace types, shapes and sizes for modern production needs.

AJAX ELECTRIC COMPANY

940 Frankford Ave.
Philadelphia 23, Pa.

Associates: Ajax Engineering Corp., Ajax Electrothermic Corp.

LEADERS IN SALT BATH PROGRESS SINCE 1936